**BONUS POSTER: THE BEST MILKY WAY IMAGE EVER**

# Astronomy®

AMERICA'S BEST-SELLING ASTRONOMY MAGAZINE

November 2001

## TWIST OF FATE

## THE MILKY WAY'S COMING DISASTER

page 38

## Predicting a Leonid Meteor Storm

## Sky Survey Reveals Hot, New Infrared Photos

## First Views of the Dark Age

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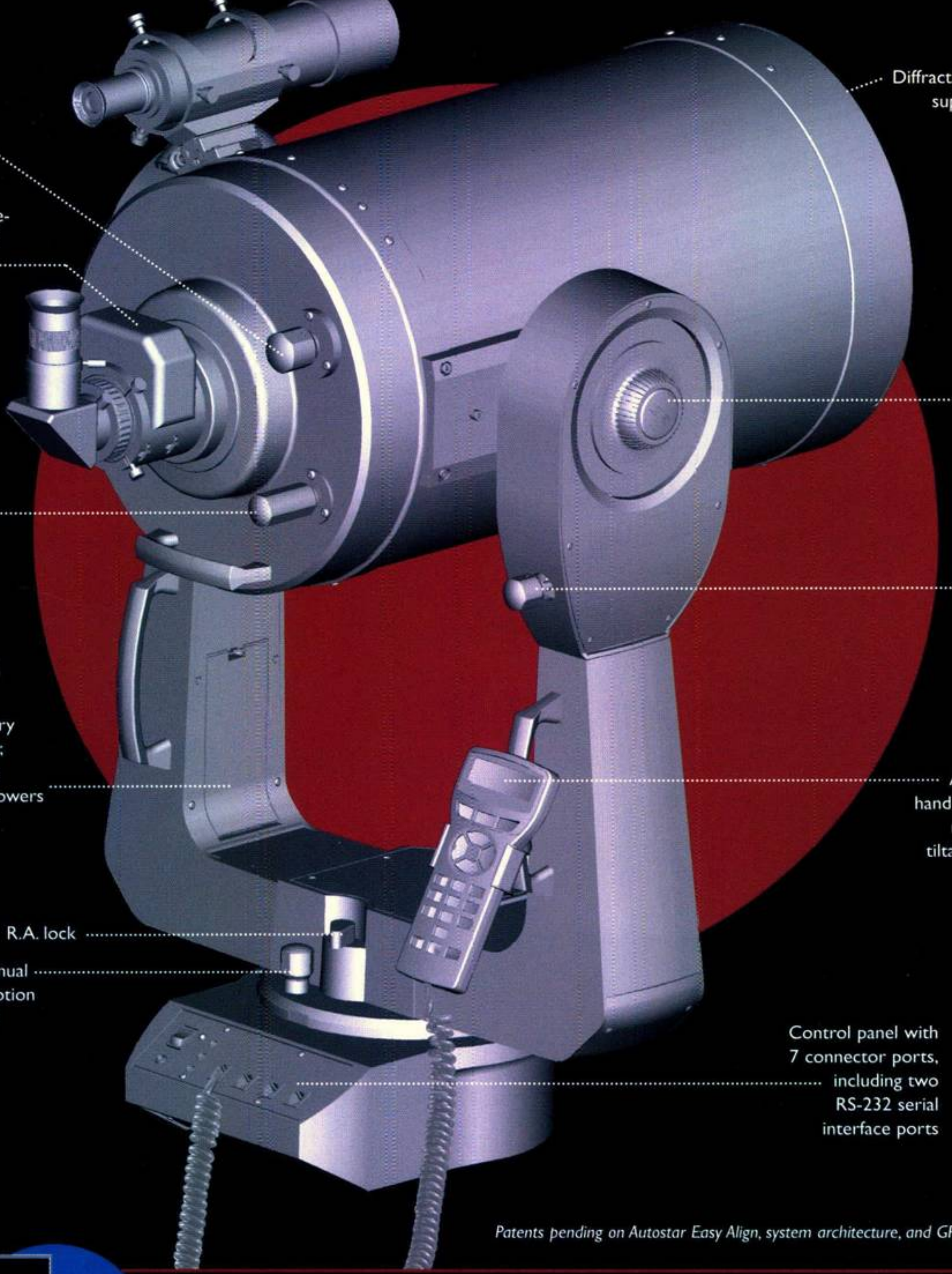
MEADE® LX200 GPS

A NEW WORLD STANDARD



Primary mirror lock; rigidly locks primary mirror in fixed position

4-speed zero image-shift microfocuser; operates through Autostar II hand controller

Coarse manual focus knob

Internal battery compartment; accepts eight C-cells and powers telescope for 40 hours

R.A. lock

R.A. manual slow-motion control

Diffraction-limited EMC super multi-coated optical system

Declination lock

Declination manual slow-motion control

Autostar II hand controller mounts on tiltable holder

Control panel with 7 connector ports, including two RS-232 serial interface ports

*Patents pending on Autostar Easy Align, system architecture, and GPS alignment procedure*

**New 2001-2002 Meade General Catalog!**
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# Meade® LX200GPS: the most important advance in Schmidt-Cassegrain technology in ten years is here.

## For the visual observer, the astrophotographer, the CCD imager: all the telescope you could possibly have imagined.

For the advanced amateur, new Meade LX200GPS telescopes offer absolutely state-of-the-art optical, mechanical, and electronic performance unmatched by any competing models. Standard-equipment features include:

**Precision GPS Alignment:** Telescope alignment is accomplished automatically using integrated true-level and North electronic sensors in combination with a 16-channel GPS receiver located in the left-hand fork arm. Magnetic declination compensation is designed into the software and automatically engaged. Just press the *ENTER* button on the Autostar II hand controller and watch as the telescope slews at 8°/second to its first alignment star. *Competing GPS telescopes use a 12-channel receiver (resulting in slower and less reliable position acquisition), do not include any magnetic declination compensation, and can easily result in first-alignment-star errors of up to 20° or more.*

AUTOSTAR II
RA = 06h34.6
Dec = +66°38
MEADE
ENTER
MODE
GO TO

**Autostar II accesses over 125,000 database objects.**

**Revolutionary new rear-cell systems designed for the advanced visual observer, astrophotographer and CCD imager —** systems that enable new levels of precision in focusing in all applications and in image centering on CCD chips:

**Primary Mirror Lock:** Flip a knob located just above the manual coarse-focus knob and lock the telescope's primary mirror rigidly in place. Used in conjunction with the Zero Image-Shift Microfocuser *(below)* the primary mirror lock completely cancels any residual image shift while focusing during visual, photographic, or CCD imaging applications.

**Zero Image-Shift Microfocuser:** Now you can obtain the most precise image focus possible — truly to a microscopic level — during visual and astrophotographic applications, and, during CCD applications, simultaneously maintain precise image centration on even the smallest CCD chips. Included as standard equipment with all LX200GPS Schmidt-Cassegrain models, the Meade Zero Image-Shift Microfocuser operates at 4 different speeds from extremely slow to fast; the entire microfocusing operation is actuated through the Autostar II handbox. Coarse manual focusing is effected through the telescope's manual focus knob.

**Autostar II**: The new Autostar II control system provided with LX200GPS models includes all of the features that made previous LX200 models the largest-selling serious telescopes in the world. In addition, Autostar II includes an expanded 3.5 Megabyte memory, permitting a greatly enlarged database of more than 125,000 celestial objects, a database that is immediately accessible on the Autostar II display. A partial listing of the Autostar II database:

| Library | No. of Objects |
|---|---|
| New General Catalog (NGC) | 7840 |
| Index Catalog (IC) | 5386 |
| Messier Catalog (M) | 110 |
| Caldwell Catalog | 109 |
| Named Objects | 227 |
| Herschel Catalog | 400 |
| Abell Catalog of Galaxy Clusters | 2712 |
| Arp Catalog of Irregular Galaxies | 645 |
| Uppsala Galaxy Catalog | 12,940 |
| Morphological Catalog of Galaxies | 12,939 |
| General Catalog of Variable Stars | 28, 484 |
| SAO and Hipparcos Star Catalogs | 31,090 |

**SPECIFICATIONS: 7", 8", 10", and 12" LX200GPS —** Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; primary mirror lock; 4-speed zero image-shift microfocuser; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and 7-port multi-function control panel, including two RS-232 serial interface ports; manual and electric slow-motion controls on both axes; Autostar II control system with 3.5 Megabyte flash memory, digital readout display, permanently programmable Smart Drive and 9-speed drive controls on both axes, High-Precision Pointing, and GO TO controller; 125,000-object onboard celestial software library; 12vDC telescope power supplied from internal battery compartments accepting 8 (user-supplied) C-cells (optional 25 ft. cords are available for powering from auto cigarette lighter plug or from 115vAC); 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); operating instructions.

### *INTRODUCTORY PRICES*
### MEADE LX200GPS
### SCHMIDT-CASSEGRAIN TELESCOPES

| | |
|---|---|
| 8" LX200GPS | **$2495** |
| 10" LX200GPS | **2995** |
| 12" LX200GPS | **3995** |
| 7" LX200GPS Maksutov-Cassegrain | **2995** |

**Packing & shipping charges** in the 48 states: 8" – $105; 10" – $145; 12" – $215; 7" – $125. Prices shown are suggested U.S. national mail-order retail prices.

**Scheduled Delivery:** October, 2001.

### A COMPARISON OF GPS SCHMIDT-CASSEGRAIN TELESCOPES

| | Meade LX200GPS | Competing 11" GPS* |
|---|---|---|
| GPS Receiver | 16-channel | 12-channel |
| Magnetic declination compensation | yes | no |
| True-level electronic sensor | yes | no |
| Primary mirror lock | yes | no |
| Zero image-shift microfocuser | yes | no |
| Permanent Periodic Error Correction | yes, both axes | one axis only; second axis unprogrammable |
| Encoder resolution | 0.10 arcsecs | 0.26 arcsecs |
| Maximum slew speed | 8°/second | 3°/second |
| Memory | 3.5-Meg flash | 1-Meg flash |
| Internal battery compartments for battery powering | yes; batteries located internal to fork arms | no |
| RS-232 software download | yes; object libraries and software downloads available | not currently available on factory website** |
| Object database | 125,000 objects | "40,000+" |
| Tracking calibration | not required | recommended after changes in telescope position or load |
| GO TO pointing precision | 2-arcmins | unstated |
| High-precision pointing mode | yes; permits GO TO pointing precision within 1-arcmin | no |

*Based on sample and instruction manual received in 7/01. ** As of 8/10/01.

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# Astronomy®

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From *The Glorious Constellations*, © 1991; Harry N. Abrams, Inc.

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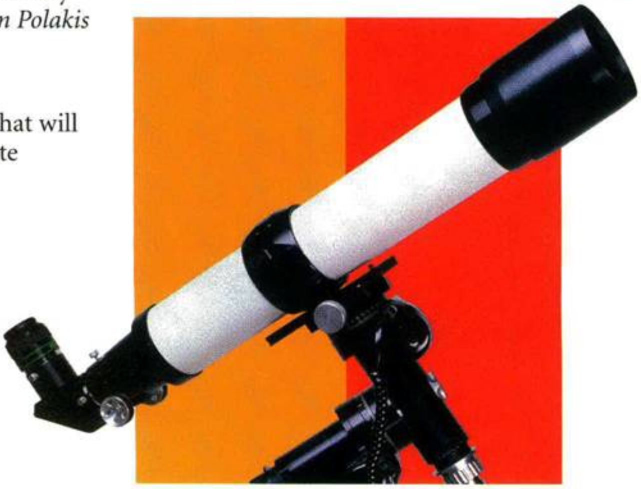
Bill Iburg



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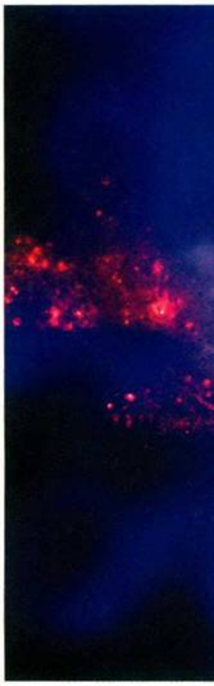

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**BEHIND THE SCENES**

BY BONNIE BILYEU GORDON

# Fresh Visions

With the November issue, *Astronomy* is expanding its presentation of beautiful and informing images with a new feature called "Sky Gem." You will be able to find Sky Gem early in each issue, so you don't have to travel far for the beauty spot. Premiere presentation goes to a magnificent image of the 30 Doradus Nebula, a fertile star-forming region with a smashing cluster of massive stars. NASA's Hubble Space Telescope snapped this panoramic portrait of gas, dust, and starbirth; find it on page 14. Consider this a bonus that derives from our original mission, to be the world's most beautiful astronomy magazine.

We are especially rich in imagery this issue. On page 58 you'll find an all-color poster image of the Milky Way as beautiful in its own right as any we have ever run. Take it out and put it on your wall if you wish, but bear in mind, the map of the Milky Way on the opposite side of the pages can vastly enlarge your knowledge of the home galaxy. You'll learn much much more about the future of the Milky Way by turning to Greg Laughlin's story about one hundred billion years of galactic evolution on page 40.

*Astronomy*/Jim Forbes

**Paul Morledge feels happiest when he's at his desk working for *Astronomy* magazine.**

Additionally, we want to introduce a new team member, associate editor Paul Morledge, who joined *Astronomy* in June 2001. Paul has had a longstanding interest in nearly all things scientific. He was graduated with a bachelor's degree in biological psychology and a minor in chemistry from the University of Colorado. He stayed on at Colorado and conducted neuroscience research in developmental memory systems with Jerry Rudy. It was during this period that he developed a passion for writing about science.

After earning a master's degree in science journalism at the University of Wisconsin, Paul was off to Chicago where he worked as the on-line science editor for Britannica.com. When the encyclopedia's journalistic offshoot cut its staff, he moved to Milwaukee and began working at Kalmbach Publishing Company as an associate editor for Astronomy.com.

In addition to reading the morning paper and daily science news, Paul enjoys cinema, sailing, biking, playing basketball, and drawing cityscapes.

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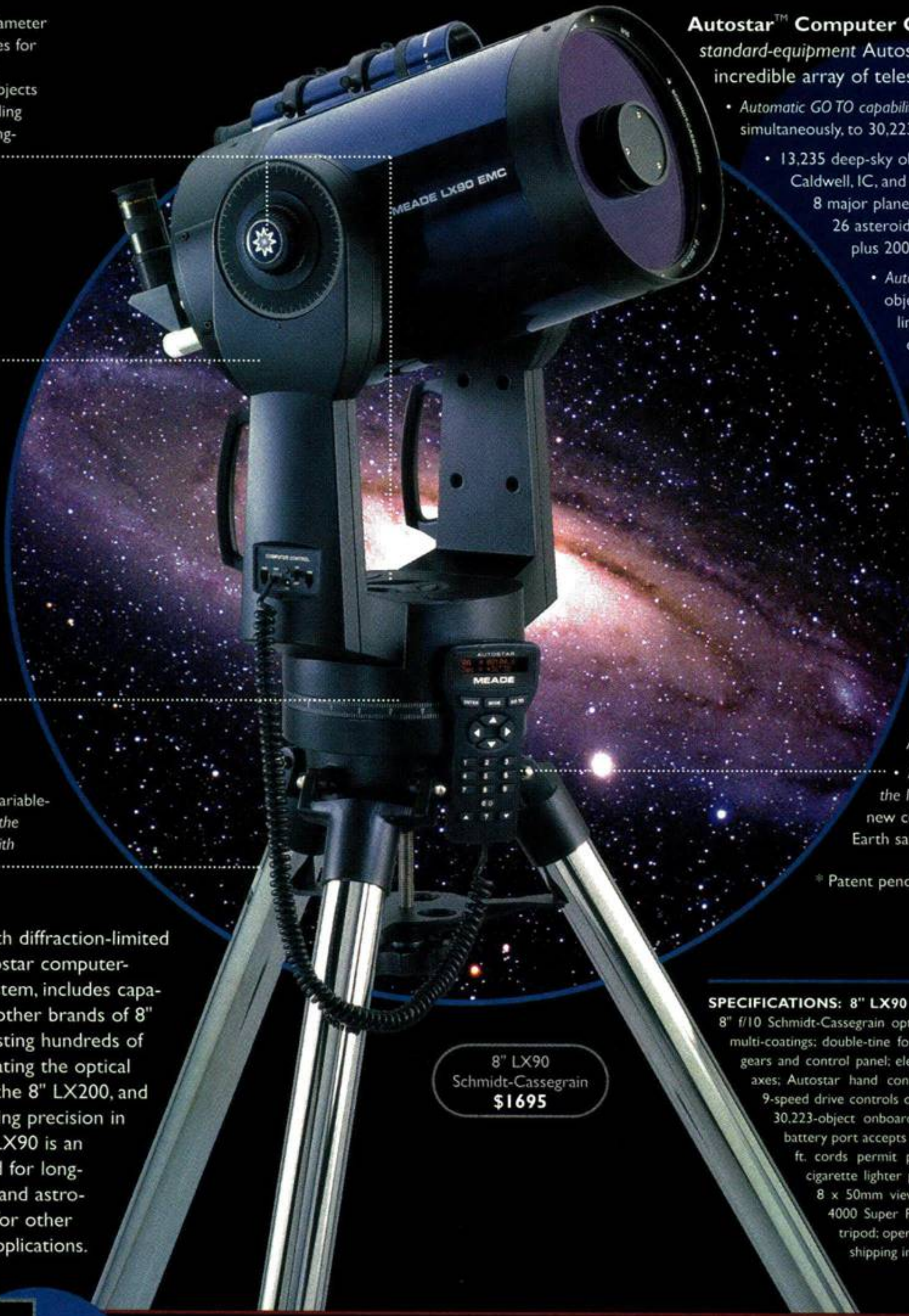
# LX90

**MEADE** 8" LX90

## THE TELESCOPE OF A LIFETIME



*Worm gears* of 4.9"-diameter on both telescope axes for smooth sidereal-rate tracking of celestial objects as well as precise guiding corrections during long-exposure imaging.

Die-cast-aluminum *double-tine* fork mount that rigidly supports the optical tube in all sky orientations.

The LX90 is powered by C-cell batteries. Alternately, the telescope may be powered from an automobile cigarette lighter plug or from a standard 115vAC home outlet, using optionally available power cords.

Rigid chromed-steel variable-height field tripod — *the same tripod provided with Meade LX200 models.*

**Autostar™ Computer Controller:** The LX90's *standard-equipment* Autostar controller permits an incredible array of telescope features:

- *Automatic GO TO capability* at 6.5°/sec on both axes, simultaneously, to 30,223 database objects, including:
  - 13,235 deep-sky objects — the complete Messier, Caldwell, IC, and NGC catalogs; 16,888 stars; the 8 major planets; the Moon; 26 asteroids; 15 comets; 50 Earth satellites; plus 200 user-defined memory locations.
- *Automatic GO TO capability* to any object of known R.A. and Declination. Plus hundreds of special event menus, guided tours, utility functions, and telescope status options.
- *Nine selectable slew speeds:* 6.5°/sec, 3°/sec, and 1.5°/sec, as well as 128x, 64x, 16x, 8x, 2x, and 1x sidereal.
- *Control of the telescope* through your personal computer. (Requires optional #505 Connector Cable Set.)
- *Fast alignment of the telescope* using any of three alignment functions, including the Meade-proprietary Easy Align*.
- *Autostar is fully upgradeable over the Internet:* add the positions of new comets, update the positions of Earth satellites, even add new software.

* Patent pending

The Meade 8" LX90, with diffraction-limited Meade optics in an Autostar computer-controlled telescope system, includes capabilities not available on other brands of 8" Schmidt-Cassegrains costing hundreds of dollars more. Incorporating the optical system and coatings of the 8" LX200, and with 5 arc-minute pointing precision in the GO TO mode, the LX90 is an instrument fully qualified for long-exposure CCD imaging and astrophotography as well as for other advanced photo-visual applications.

8" LX90
Schmidt-Cassegrain
**$1695**

**SPECIFICATIONS: 8" LX90 —** Each complete telescope includes 8" f/10 Schmidt-Cassegrain optical tube assembly with EMC super multi-coatings; double-tine fork mount with dual-axis 4.9" worm gears and control panel; electric slow-motion controls on both axes; Autostar hand controller with digital readout display, 9-speed drive controls on both axes, and GO TO controller; 30,223-object onboard celestial software library; internal battery port accepts 8 (user-supplied) C-cells (optional 25 ft. cords permit powering from either 12vDC auto cigarette lighter plug or from 115vAC home outlet); 8 x 50mm viewfinder; 1.25" diagonal prism; Series 4000 Super Plossl 26mm eyepiece; standard field tripod; operating instructions. **$1695**. Packing & shipping in the 48 states: $95.

**New 2001 126-page Meade General Catalog!**

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# LXD55

MEADE

6" 8" 10"

SCHMIDT-NEWTONIANS WITH AUTOSTAR®

## Now you can buy a Meade Schmidt-Newtonian telescope with Autostar dual-axis GO TO drive system for as little as $599, *complete!*

*Shown:* Meade 8" f/4 LXD55 Schmidt-Newtonian Telescope with standard-equipment Autostar Control System

### MEADE LXD55 SCHMIDT-NEWTONIAN TELESCOPES

*Shipped complete per specifications below:*

| | |
|---|---|
| 6" LXD55 Schmidt-Newtonian | **$599** |
| 8" LXD55 Schmidt-Newtonian | **729** |
| 10" LXD55 Schmidt-Newtonian | **879** |

**Packing & shipping charges** in the 48 states: 6" – $75; 8" – $85; 10" – $95. Prices shown are suggested U.S. national mail-order retail prices.

**SPECIFICATIONS: 6", 8", and 10" LXD55-Series Telescopes** — Each complete telescope includes 6" f/5, 8" f/4, or 10" f/4 Schmidt-Newtonian optical tube assembly with EMC super multi-coatings; quick-attach cradle ring assembly with locks; 6 x 30mm achromatic viewfinder; all-metal rack-and-pinion focuser with eyepiece holders for both 1.25" and 2" eyepieces; Series 4000 Super Plössl 26mm eyepiece. LXD55 German-type equatorial mount with worm gear drives and electric slow-motion controls on both axes; micrometric controls for azimuth and elevation adjustments; illuminated polar alignment finder with reticle; variable-height field tripod with accessory shelf. Autostar dual-axis control system with digital readout display; 9-speed drive controls; 30,223-object celestial software library and automatic GO TO object-locating. Battery pack accepting eight (user-supplied) D-cells (optional 25 ft. cords permit powering from either 12vDC auto cigarette lighter plug or from 115vAC home outlet); operating instructions.

**New 2001-2002 Meade General Catalog!**
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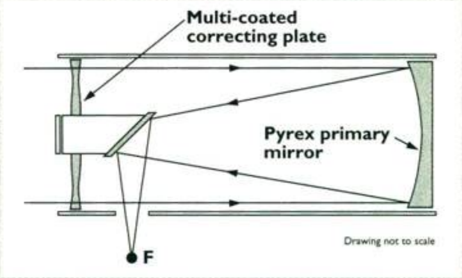
## Every Meade LXD55-Series Schmidt-Newtonian telescope includes this listing of standard equipment:

**Schmidt-Newtonian optical systems:** Manufactured entirely at the Meade Irvine facility, LXD55 diffraction-limited Schmidt-Newtonian optics yield pinpoint stellar images over extremely wide fields, with *one-half* the coma of paraboloids of the same focal ratios. Combined with fast f/4 (8", 10") or f/5 (6") optics, the standard-equipment Super Plössl 26mm eyepiece yields an actual field in excess of 1.3°, for brilliant, rich-field imaging of nebulae, galaxies, and star clusters. High-power lunar and planetary images reveal subtle detail often lost in telescopes of lesser optical resolution. The optics are mounted in machined aluminum cells fitted to white-enameled metal tubes; each tube accepts the giant Meade rack-and-pinion focuser with eyepiece holders for both 1.25" and 2" eyepieces.



**The Meade Schmidt-Newtonian Optical System.**

**LXD55 Equatorial Mount:** Designed by Meade engineers and manufactured of machined aluminum for high-performance photo-visual observing, the new Meade LXD55 mounting moves effortlessly across the skies in either tracking or automatic GO TO modes. Included is an illuminated polar viewfinder for quick, precise polar alignment.

**All LXD55 telescopes** include an illuminated polar alignment finder as standard equipment.

**Autostar Dual-Axis Electronic Control System:** A revelation of advanced electronic and software design, the exclusive patent-pending Meade Autostar system, included as standard equipment with every LXD55 telescope, permits an amazing range of capabilities never before offered on telescopes in this price and aperture class:

*Automatic GO TO capability* at 4.5°/second on both axes simultaneously, to 30,223 database objects, including:

13,235 deep-sky objects — galaxies; diffuse and planetary nebulae; star clusters; the complete Messier, Caldwell, IC, and NGC catalogs.

16,888 stars sorted by name, SAO catalog numbers, double and variable stars.

50 objects in the Solar System; 8 major planets from Mercury to Pluto; the Moon; 26 asteroids; 15 comets.

50 Earth satellites; 200 memory locations for user-defined objects.

*Automatic GO TO capability* to *any* object of known R.A. and Declination.

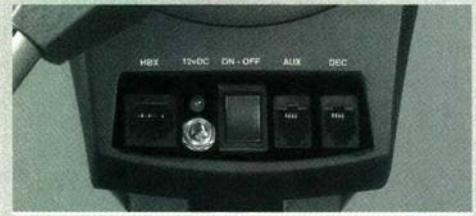
*Nine selectable slew and slow-motion speeds:* 4.5°, 3°, and 1.5°/sec, 128x, 64x, 16x, 8x, 2x, and 1x sidereal.

*Automatic sidereal-rate tracking in R.A.* keeps objects precisely centered in the field.

*Control of the telescope through your PC and full upgradability over the Internet,* using the RS-232 serial interface. (Requires optional #505 Connector Set.)

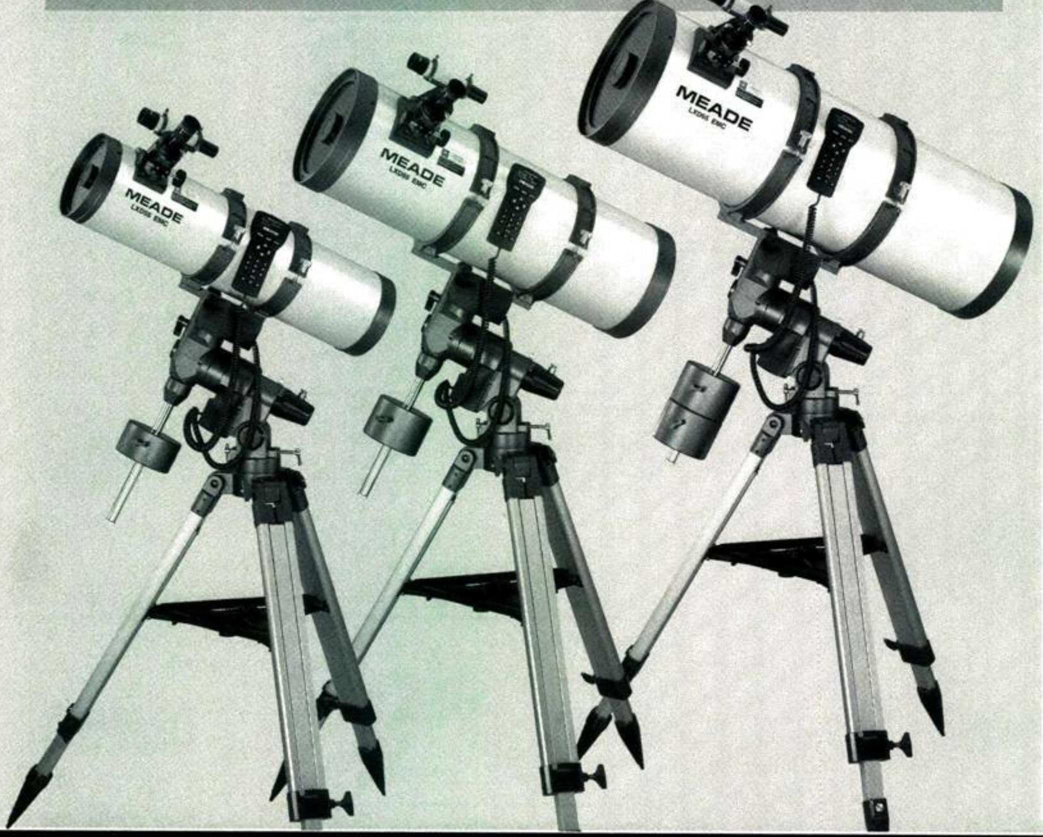
**Battery Pack (12vDC):** Included with each LXD55 telescope; rests on the telescope's accessory shelf and plugs into the control panel. The battery pack accepts eight (user-supplied) D-cell batteries, which power the telescope for more than 40 hours.

**Astrophotography and CCD imaging:** Armed with their fast photographic speeds, Meade LXD55 Schmidt-Newtonians are ideally suited for deep-space astrophotography and CCD imaging at the telescope's prime focus.



**The LXD55 control panel** is located below the upper bearing of the polar axis.

***Below, left to right:* Meade 6" f/5, 8" f/4, and 10" f/4 LXD55 Schmidt-Newtonian telescopes.** Each telescope is shipped complete with all equipment shown.



**Meade LXD55 Schmidt-Newtonians** open up the skies to images and capabilities previously unavailable in telescopes of their aperture and price level. Consider what a Meade LXD55 telescope can do for your observing program:

**6" LXD55 –** Observe ***hundreds*** of galaxies, nebulae, and star clusters of all types ***your very first night out,*** and hundreds more the next night out, simply by pressing the Autostar GO TO pushbutton. Watch as the telescope moves effortlessly and automatically from major planet to asteroid to galaxy to nebula at 4.5°/second, placing every object in the center of the telescopic field. Study fine fault lines on the Moon, structural detail in Jupiter's cloud belts and Red Spot, the Cassini division in Saturn's rings, and much more.

**8" LXD55 –** With 78% more light-gathering power than the 6" model, the 8" LXD55 roughly triples the number of observable objects in deep-space and resolves extremely fine planetary detail as well: Jupiter's cloud belts are seen as a web of intricate discontinuities; transits and shadow transits of Jupiter's main satellites are observable; six of Saturn's satellites may be seen in revolution about the planet. Deep-space phenomena take on new character with the larger 8" aperture, as Autostar moves the telescope automatically from one spectacular object to the next. CCD images at the telescope's prime f/4 focus show a new level of resolution and detail after only a few minutes' exposure.

**10" LXD55 –** A quantum leap in image brightness and resolution, the 10" LXD55 provides for a lifetime of serious study in deep-space or within the Solar System. Use Autostar to take an automatic tour, on any given evening, of, say, the 200 brightest diffuse nebulae, spiral galaxies, and globular star clusters. Or, with Autostar's pushbutton electronic slow-motion controls, scan the surface of the Moon at high magnification. Let Autostar locate and center in the field the outer planets Uranus and Neptune, now visible as finite-sized orbs, or Pluto, at the telescope's very limit of observability. It is an uncommon observer who might outgrow the capabilities of the Meade 10" LXD55.

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**Orders: 800-422-7876; Info.: 405-364-0858.**

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**Orders & Information: 416-787-4581.**

**KHAN SCOPE CENTRE, Toronto, Ontario, Canada**
**Orders & Information: 416-783-4140.**

# RESEARCH-GRADE ACCESSORIES

## Series 4000™ Super Plössls
## 52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

**Super Plössls** (SP; 4-elements; 1.25"; 52°):

| | | | |
|---|---|---|---|
| **6.4, 9.7, 12.4, 15, 20, 26mm** | each: | **$79.95** | (4.54) |
| **32mm** (52°); **40mm** (44°) | each: | **99.95** | (5.26) |
| **56mm** (52°; 2") | | **199.95** | (7.02) |

## Series 4000™ Ultra Wide Angle 84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

**Ultra Wide Angle** (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (5.26); **6.7mm: 199.95** (5.26); **8.8mm** (1.25"/2"): **239.95** (7.02); **14mm** (1.25"/2"): **299.95** (7.02)

## Series 4000™ f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture. **$129.95** (5.26)

## 2x Telenegative Barlow (1.25")

**#122:** Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

**$47.95** (4.54)

## 2x Short-Focus Barlow (1.25")

**#126:** Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated.

**$47.95** (4.54)

## 2x-3x Variable Barlow (1.25")

**#127:** Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

**$59.95** (4.54)

## 2" Diagonal Mirror

**#929:** Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

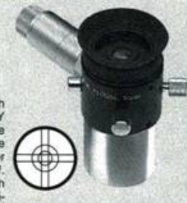
**#929** or **#930,** each: **$99.95** (6.85)

## 45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

**$42.95** (3.86)

## World's Most Advanced Illuminated Reticle Eyepiece



**Series 4000 Plössl 9mm,** with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

**$149.95** (6.14)

**Series 4000 Plössl 9mm**—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

**$129.95** (5.26)

**Series 4000 Photo-Visual Color Filters** (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

**#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue**

each **$14.95** (2.73)

| | | |
|---|---|---|
| **Set #1**–4 filters: #12, #23A, #58, #80A | **49.95** | (4.54) |
| **Set #2**–4 filters: #11, #25A, #47, #82A | **49.95** | (4.54) |
| **Set #3**–4 filters: #8, #21, #38A, #56 | **49.95** | (4.54) |

**Series 4000 Moon Filter (#ND96):** Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.73)

## #905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (5.26)

## Electric Focusers for SCT's

For extremely smooth microfocusing of the image. Does not affect use of the manual coarse-focus knob.

**#1206 Electric Focuser:** Plugs into control panel of Meade 8", 10", 12" LX200 models and operates from LX200 hand controller. **$149.95** (7.48)

**#1205 Electric Focuser:** For **all** other Meade 8", 10", 12" SCT models; includes separate hand controller; accepts one self-contained (user-supplied) 9v. battery.

**$169.95** (7.88)

## #777 Off-Axis Guider for SCT's

Internal prism diverts light for monitoring telescopic image during long-exposure astrophotography. Threads to any Meade or Celestron rear cell. Use with illuminated reticle eyepiece and T-Mount for your 35mm camera.

**$79.95** (6.85)

## Series 4000™ 2x Apochromatic Barlow Lens

**#140:** The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

**$79.95** (5.26)

## Series 4000™ Super Wide Angle 67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

**Super Wide Angle** (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (4.54); **18mm: 149.95** (4.54); **24.5mm: 179.95** (5.26); **32mm** (2"): **239.95** (7.02); **40mm** (2"): **299.95** (7.02)

## Series 3000™ Plössls 50° field; multi-coated

Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Focal lengths from 5mm through 25mm are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. All eyepieces are fitted with fold-down rubber eyecups for comfortable observing. The PL40mm *(far right in photo)*, an excellent complement to any ocular set, produces spectacular low-power, wide fields, ideal for scanning the Milky Way. Manufactured exclusively to Meade optical designs, Series 3000 Plössls yield fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

**Series 3000 Plössls** (4-elements; 1.25"; 50°)

**5, 6.7, 9.5, 16, 25mm** each: **$49.95** (3.86); **40mm** (44° field): **$79.95** (3.86)

#911B
#910B
#908B

#911N
#910N
#908N

**Series 4000 Nebular Filters**—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

| | | |
|---|---|---|
| **#908B**–Threads into 1.25" eyepieces, 26mm dia. | **79.95** | (4.54) |
| **#910B**–Threads into 2" eyepieces, 44mm dia. | **119.95** | (5.26) |
| **#911B**–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. | **99.95** | (5.26) |
| **#908N**–Threads into 1.25" eyepieces, 26mm dia. | **89.95** | (4.54) |
| **#910N**–Threads into 2" eyepieces, 44mm dia. | **129.95** | (5.26) |
| **#911N**–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. | **119.95** | (5.26) |

#911X
#910X
#908X

**Series 4000 Oxygen-III Filters** Observe diffuse emission and planetary nebulae as you never thought possible! Exclusive Meade *60-layer* interference coating technology isolates the 496nm and 501nm O-III lines to tremendously enhance observable nebular structural detail in all telescopes.

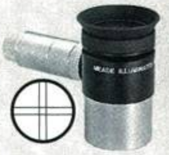
| | | |
|---|---|---|
| **#908X**–Threads into 1.25" eyepieces, 26mm dia. | **99.95** | (4.54) |
| **#910X**–Threads into 2" eyepieces, 44mm dia. | **159.95** | (5.26) |
| **#911X**–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. | **149.95** | (5.26) |

## Vibration Isolation Pads

Designed by Meade engineers, these isolation pads reduce typical telescope-tripod vibration damping times to *less than one second.* A tremendous aid for both visual and photographic astronomy. Place one pad under each tripod leg. #895 Vibration Isolation Pads, per set of three:

**$49.95** (6.85)

## MA12mm Illuminated Reticle Eyepiece



Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle; rubber eyecup. Wireless red LED illuminator and variable brightness control. 1.25". **Batteries included.**

**$99.95** (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (5.26)

## Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

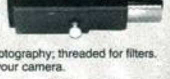
**.965": $27.95**; **1.25": $29.95** (3.86)

## Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

**$39.95** (3.86)

## Variable-Projection Camera Adapter (1.25")



Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

**$39.95** (3.86)

## T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

**$26.95** (3.86)

## CCD-Photo-Visual Flip-Mirror Systems

An essential accessory for imaging with ***any*** brand of CCD imager or for astrophotography with a 35mm camera. Flip mirror "down" to center the image while viewing with an eyepiece at 90°; flip mirror "up" to pass light on to CCD chip or 35mm camera film plane. Each unit includes: precision optical-flat Pyrex® mirror; 2-axis mirror-adjustment screws and locks for precise image centering; extra-fine helicoid focusing of the eyepiece; extension tubes for attaching either 35mm camera (using T-Mount) or CCD imager (using either T-threads or 1.25" barrel). Threads to rear cells of all Schmidt-Cassegrain telescopes; may remain on telescope and used in place of diagonal prism for visual observing as well.

*"Over the past 10 years I have used all manner of flip-mirrors. The Meade Flip-Mirror Systems are absolutely the best—rock solid, high-precision, beautifully manufactured; they virtually eliminate all flexture between the CCD and telescope."* — Jack Newton

**#644 Flip-Mirror System:** Accepts any 1.25" eyepiece. Mirror clear aperture: 22mm. Use with CCD's up to Pictor 416XT or ST-7, or smaller; or visual observing with 1.25" eyepieces. **$149.95** (7.02)

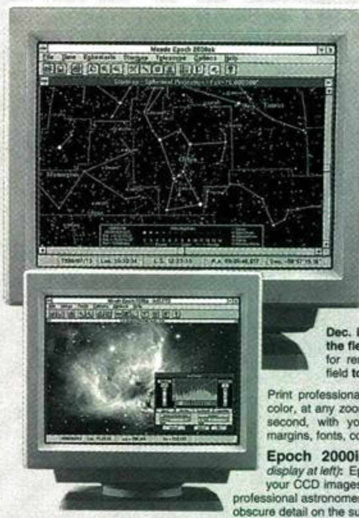
**#647 Flip-Mirror System:** Accepts either 1.25" or 2" eyepieces. Mirror clear aperture: 40mm. Recommended for full-field 35mm astrophotography or with CCD's of any size, including all Meade Pictor Series through 1616XT, as well as ST-4 through ST-10; or for visual applications with 1.25" or 2" eyepieces. **249.95** (8.49)

**#157 1.25" Adapter:** Permits use of either Flip-Mirror on telescopes with 1.25" eyepiece-holders. (Requires approx. 2" additional focus travel with #644, 3" with #647.) **15.00** (3.86)

#644

#647

MEADE
FLIP-MIRROR SYSTEM



## Epoch 2000® Sky Software

### The most powerful astronomical software ever made available can now be yours for only $149!

**Epoch 2000sk** *(upper display at left):* Now you can use the most advanced, most precise full-color sky software ever created, to zoom-in on telescopic fields **smaller than one arc second!** With star positions displayed as precisely as **0.01 arc second,** the Trapezium in Orion is no longer shown as a single point, as in other software, **but as four precisely oriented starpoints, just as they appear in the telescope.** No longer do you need to guess the R.A. and Dec. of an object located away from the field center, as in other programs: Epoch 2000sk dynamically reads out the R.A. and Dec. of the cursor position anywhere in the field **and updates R.A. and Dec. instantaneously as the cursor is moved about the field.** Meade LX200 owners can use Epoch 2000sk for remote auto-centering of objects in the telescopic field **to a precision of 30 arc seconds,** routinely!

Print professional-quality star charts in either black-and-white or color, at any zoom setting or sky scale between 180° and one arc second, with your own customized borders, headers, footers, margins, fonts, colors, and grids.

**Epoch 2000ip Image Processing Software** *(lower display at left)*: Epoch 2000ip makes it easy to enhance and analyze your CCD images with the same sophisticated techniques used by professional astronomers to uncover hidden structure in a spiral galaxy or obscure detail on the surface of a planet. This powerful software includes virtually every technique available for image enhancement. Techniques that bring out detail totally invisible in your original image, transforming it from the ordinary to the spectacular.

**EPOCH 2000sk Sky Software:** 281,000 objects supplied on 3.5" discs for Windows 3.1 or higher; fully compatible with Windows 95 . . . . . . **$149**

**EPOCH 2000sk-CD Sky Software:** 19 million objects, including the complete Hubble Guide Star Catalog; supplied on CD-ROM . . . . . . **179**

**LX200 Interface Cable:** for Meade LX200 operation by Epoch 2000sk . . . . . . **25**

**EPOCH 2000ip Image Processing Software:** Supplied on 3.5" discs for Windows 3.1 or higher; fully compatible with Windows 95 . . . . . . **$199**

f/3.3 CCD FOCAL REDUCER

## Series 4000™ f/3.3 CCD Focal Reducer/Field Flattener

Revolutionary 3-element Meade design permits ultrafast CCD imaging with **increased** edge-of-field resolution and color correction! Reduces CCD exposure times by up to 80%. Threads on to the rear cell of any Meade or Celestron Schmidt-Cassegrain. Converts f/10 Schmidt-Cassegrain telescopes to **f/3.3** and f/6.3 SCT's to **f/2.** Variable T-Adapter (included) allows range of f/ratios between f/3 and f/5 on f/10 SCT's and between f/1.9 and f/3.2 on f/6.3 SCT's. Use with CCD imagers of any brand and chip dimensions. Not for visual or photographic applications. Multi-coated; 41mm clear aperture. **$149.95** (5.26)

## Plössl 25mm Illuminated Reticle CCD Framing Ocular

MEADE
PLÖSSL
CCD FRAMING

Displays rectangular frames of all popular CCD chip sizes, including all Meade Pictor models and ST-4 through ST-8. Shows precisely the image size and orientation that appear on CCD chip. Insert directly into telescope eyepiece-holder, or use with Flip-Mirror *(above)*. Includes 4-element coated Plössl optics; lockable spacer ring to fix focus position; rubber eyecup; variable LED illumination control; batteries. 1.25". **$129.95** (4.54)

## #825 8 x 25mm Right-Angle Viewfinder for ETX-90

Permits comfortable right-angle viewing. Replaces standard-equipment finder on 90mm ETX models, using the same bracket. Wide-angle, achromatic, coated optics; actual field 7.5°. Precise helicoid focusing. **$49.95** (4.26)

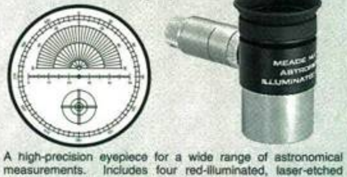
## #64 T-Adapter for ETX®

Threads to photo port of all ETX-90, ETX-105, and ETX-125 models. Rigidly couples any 35mm camera with removable lens to the telescope for lunar, planetary, or terrestrial photography. Includes extension tube for longer effective focal length, if desired. Use with T-Mount for your 35mm camera. **$34.95** (3.86)

## #932 45° Erecting Prism for ETX®

For terrestrial observing with any ETX-90, ETX-105, or ETX-125 model. Yields correctly oriented image and convenient 45° observing angle. Threads to ETX rear cell. Accepts any 1.25" eyepieces. Coated roof prism optics. **$49.95** (3.86)

## MA12mm Illuminated Reticle Astrometric Eyepiece



A high-precision eyepiece for a wide range of astronomical measurements. Includes four red-illuminated, laser-etched scales for measuring double star angular separations, position angles, planetary diameters, and lunar crater diameters, and for long-exposure photo-guiding. Modified Achromatic 3-element coated optics; diopter adjustment; rubber eyecup; variable LED illumination control; batteries. 1.25". **$119.95** (4.26)

## Series 4000™ 8mm – 24mm Zoom Eyepiece

The finest zoom eyepiece available. High-resolution 7-element multi-coated optics, with 55° field at 8mm. Graduated scale in 1mm units indicates exact focal length in use. High-eyepoint yields comfortable observing even with eyeglasses. Internal zoom lenses move on the smoothest, most precisely-machined tracks yet developed for zoom optics. Performance is fully consistent with the finest fixed-focal length eyepieces. Threaded for filters; rubber eyecup; 1.25". **$219.95** (6.38)

## ETX® Hard Carrying Cases

For secure storage or travel with your ETX. Thick-wall construction and die-cut foam lining. Accepts telescope, optional eyepieces, erecting prism, table tripod, hand controller, *etc.* Includes steel latches & key.

**#774** Case for ETX-90 models: **99.95** (8.58)

**#776** Case for ETX-105EC: **99.95** (8.58)

**#775** for ETX-125EC: **149.95** (13.38)

## Dew Shields for ETX®

Threads into the front-lens cell and effectively inhibits the formation of dew on the lens surface.

| | |
|---|---|
| **#670** for ETX-60/70 | **$19.95** |
| **#673** for ETX-90 | **24.95** |
| **#675** for ETX-105 | **27.95** |
| **#678** for ETX-125 | **29.95** |

## Advanced Field Tripod for ETX-125

**#887:** Yields *rock-solid* stability for sensitive applications of the ETX-125, even at high magnifications. **Includes fixed-height tripod convenient for standing observations, equatorial wedge with alignment controls in azimuth and latitude angle, and #889 Tripod Adapter for ETX-125.** Permits either altazimuth or equatorial orientation of the telescope for astronomical or terrestrial observing. Tripod legs are 2"-diameter chromed steel. For field use the tripod collapses for easy transport. **$349.95** (14.00)

## Tripod Adapter for ETX-125

Included with the #887 Tripod *(above)*, the #889 Adapter is available separately and permits attachment of ETX-125 directly to any Meade LX10, LX50, or LX200 Schmidt-Cassegrain Field Tripod for altazimuth observing or to any Meade Schmidt-Cassegrain Tripod-with-Equatorial Wedge or Superwedge for equatorial applications.

**#889 Adapter:** **$69.95** (7.70)

## ETX® Deluxe Field Tripod

**#883:** Designed specifically for ETX-90, ETX-105, and ETX-125 Astro Telescopes. Tripod height adjusts from 34" to 54", for seated or standing observations. Micrometric controls in azimuth and elevation permit precise polar alignment of the ETX fork mount. Tripod head tilts and locks to 90° for terrestrial applications. Telescope attaches to tripod in seconds with 2 thumbscrews. All-aluminum construction. **$199.95** (10.00)

## #772 Carry Bag for Deluxe Field Tripod

Custom-fitted Cordura-type bag permits easy portability and storage of the #883 Tripod, above. Includes carry strap, accessory pockets. **$49.95** (6.40)

## ETX® Carry Bag

Soft-padded Cordura-type carry bag with shoulder strap; permits storage of any 90mm ETX model, plus table tripod legs, eyepieces, other accessories. **$36.95** (5.26)

## Electric Focusers for ETX®

ELECTRONIC CONTROLLER
MEADE

Meade-engineered for smooth, rapid focusing with any ETX model. Four-speed operation from coarse to microfine. Standard-equipment hand controller accepts one 9v. (user-supplied) battery and focuses all ETX telescopes. Or focus ETX/EC models through the telescope's hand controller.

**#1244 Electric Focuser** for all ETX-90 and ETX-105 models: **$119.95** (6.85)

**#1247 Electric Focuser** for ETX-125 models: **$119.95** (6.85)

# HOW TO ORDER

Prices shown are suggested U.S.A. mail-order retail prices and do not include any applicable sales taxes. Suggested shipping and handling charges to the 48 states by U.P.S. or U.S. Mail shown in ( ) next to each price. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

**ASTRONOMICS, Norman, OK.**
**Orders: 800-422-7876; Info.: 405-364-0858.**

**FOCUS CAMERA, Brooklyn, NY.**
**Orders: 800-221-0828; Info.: 718-436-6262.**

**LUMICON, Livermore, CA.**
**Orders: 800-767-9576; Info.: 925-447-9570.**

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**Orders & Info.: 800-621-2248; IL: 847-367-4600.**

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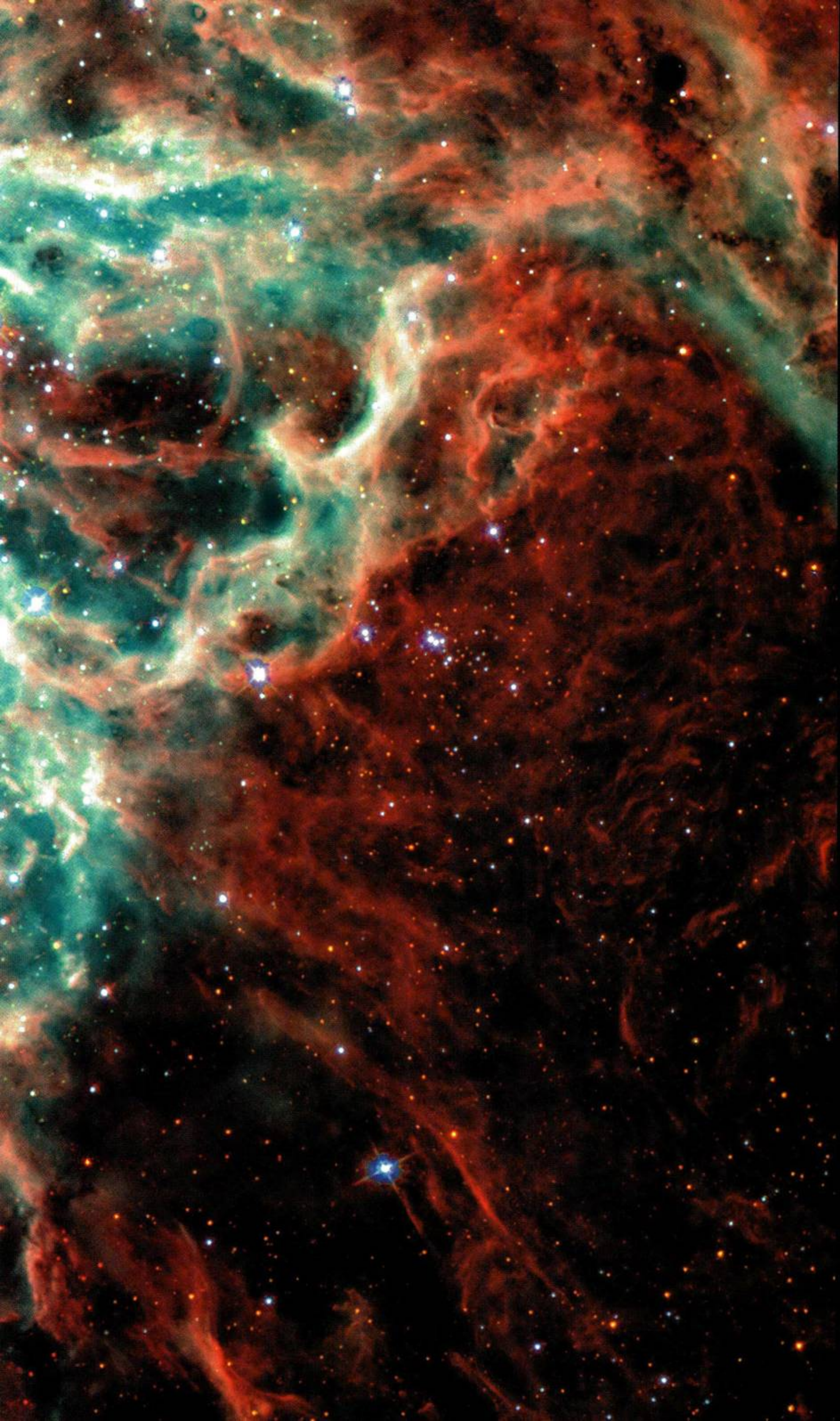


# Deep in the Spider's Lair

**At the heart of the Large Magellanic Cloud's Tarantula Nebula, blistering ultraviolet radiation and billowing winds from R136 (cluster at left) stoke the smoldering fires of star formation.**

HST/NASA/STScI/N. Walborn/J.Maiz-Apellaniz/R. Barba

TALKING BACK
FROM OUR READERS

# Water Means Life?

You do not necessarily need water for life, as assumed in "Is There Life Under the Ice?" and "What's Water Got to Do With It?" (August 2001).

Even on Earth, deep-ocean hydrogen-sulfur vents host microorganisms and bacteria based on $H_2S$ instead of $H_2O$. Organic chemists synthesize many molecules of high complexity by substituting carbon for silicon. It could be worthwhile to look after these to find life elsewhere. — *Horand Rittersbacher, Böblingen, Germany*

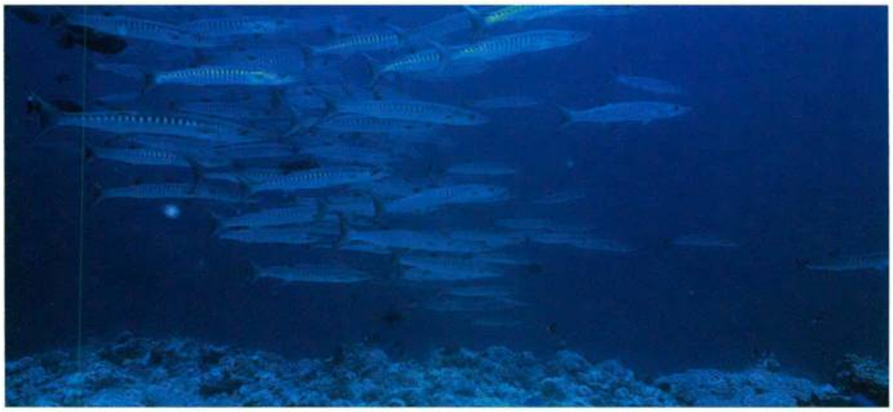
Why it is so difficult for some people to believe that life and/or water exists on probably billions of planets within the universe? Who's to say that under the ice of Europa, there aren't huge watery creatures like whales or dolphins? If the ingredients for life exist on Earth, then it's only logical that they exist elsewhere. — *Larry Leaird, Newton, Kansas*

### Changing Times

Two of your recent articles have taken me back to 1927–1931, when I was an astronomy major at Mount Holyoke College in South Hadley, Massachusetts. During one course we painstakingly measured glass plates, as shown in "Digitizing Astronomy's Glass Plates" (July 2001). We hand-turned a little crank to move the plate from left to right, or up and down.

Also, "Reluctant Astronauts" (April 2001) reminded me of watching Sputnik 2 from the hillside on our farm. There it was, passing near the two dog stars, Sirius and Procyon, and carrying Laika, a stray husky, on board.

While my own dog had followed me up the hill and sat beside me, I never realized the fate of the creature within that bright "star." I surely hope that useless experiments on animals in space will not be performed in the future. — *Florence Byrd Woods, Bath, New Hampshire*



Carol Ryback

**Are creatures like these Blackfin barracuda** *(Sphyraena genie)* **unique to Earth?**

### Spinning Singularities

"Black Hole Goes for a Spin," ("AstroNews," August 2001) asks readers to believe the idea that black holes can spin. I realize that the theorists must somehow account for the angular momentum of the material that went into forming the black hole. But a rotating object with infinite density — mass, but no volume? What does this actually mean? We seem to have a convenient mathematical model that defies physical description. — *Ken Dixon, Toronto, Ontario, Canada*

*The known laws of physics are moot when it comes to a complete description of a singularity. And until a theory of quantum gravity exists, singularities will continue to puzzle scientists. These same physical laws, however, also indicate that a singularity lies at the heart of every black hole.*

*Although a black hole's event horizon cloaks its singularity from view, the mysterious innards of black holes make themselves known from the outside. An event horizon's behavior (and that of the space surrounding the black hole) is directly influenced by the singularity inside. Astronomers can make predictions about how the exterior of a black hole should behave.*

*Theory predicts that spinning black holes will have deformed singularities (an infinitely dense ring rather than a point) and an ellipsoidal (rather than spherical) event horizon. Moreover, spinning black holes should drag nearby spacetime along with them. Goddard Space Flight Center researcher Tod Strohmayer's recent detection of such space tugging around microquasar GRO J1655–40 confirms that black hole theorists have been on the right track all along.* — William Schomaker, associate editor

### Red Gem

Alan Dyer's photo of the famous "Double-Double" ("Sky Show," August 2001) also captured T Lyrae, one of the most visually red "gem" stars in the sky. It's located on the right side of Vega, about 45° down and a little farther away from Vega than is the Double-Double. Great shot! — *Gene Dolphin, San Diego, California*

The August 2001 "Sky Show" says that "Mars appears to veer left" (page 52). If Earth outruns Mars to the left — which is east on the Northern Hemisphere — wouldn't that mean that Mars's apparent motion is to the right? — *Burkhard Klesser, Teufenthal, Switzerland*

*You're thinking along the right lines. When Earth passed directly between Mars and the sun (at opposition in June), Mars appeared to move westward*

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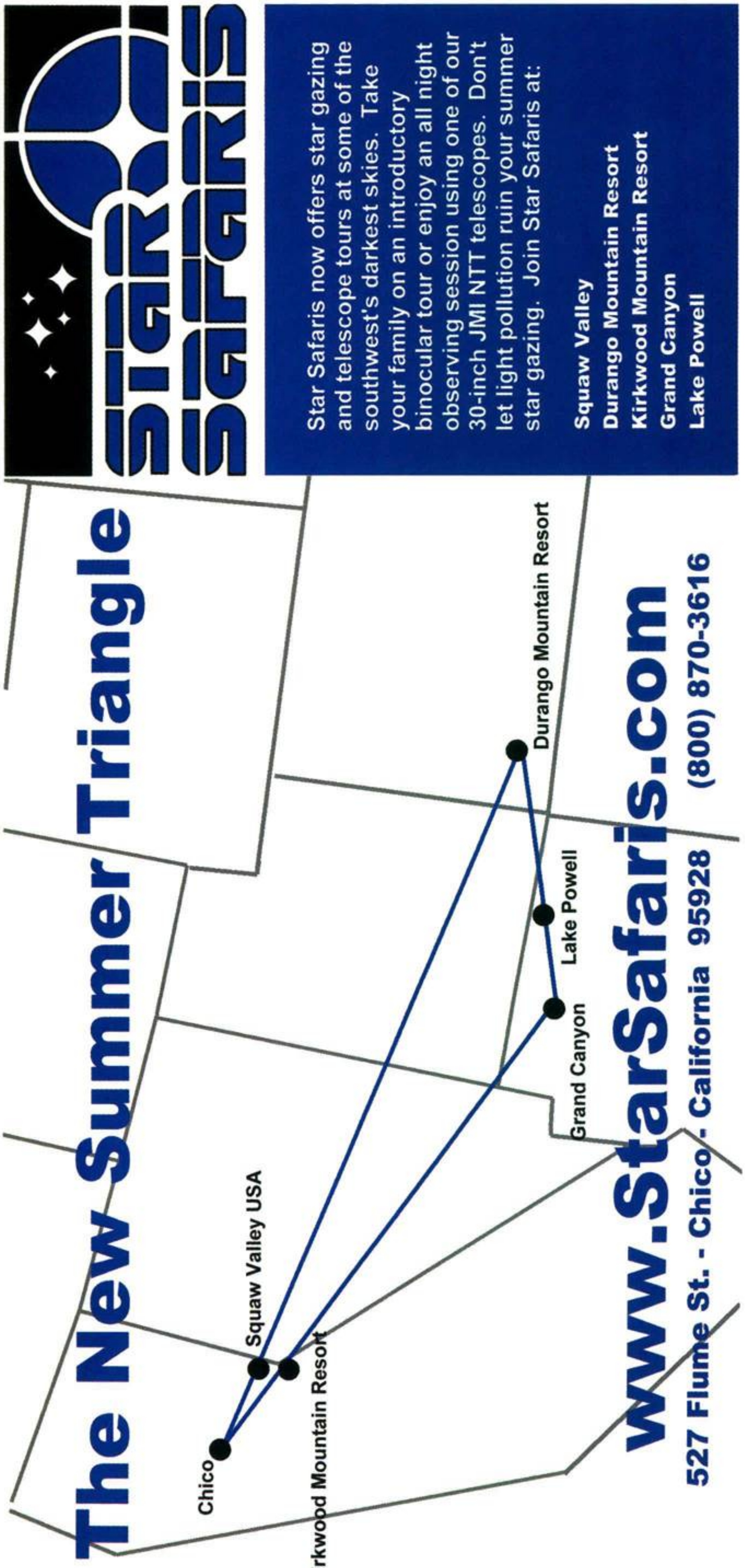

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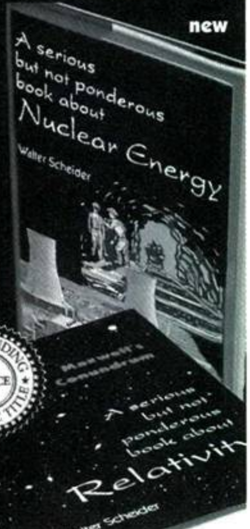
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*(to the right). By August we traveled far enough ahead of Mars in our orbit so that we were moving mostly away from Mars — and Mars's eastward motion won out.* — Rich Talcott, senior editor

### Universal Genius

After reading "Quick Trip to Andromeda" (August 2001), I want to congratulate Bob Berman on his wonderful "Strange Universe." Berman's style is excellent, reminiscent of Carl Sagan's witty analogies and imaginative speculation. You've found a literary genius and a magazine-seller. — *Matthew Steele, Palos Verdes, California*

### Pluto Mission Bites the Dust

In "Event Horizon" ("AstroNews" July 2001), NASA Administrator Dan Goldin is quoted as justifying his reason for axing the Pluto mission in order to dedicate more funding to the Mars exploration program instead. Dan Goldin is wrong.

There is always next year for Mars, but if the Fiscal Year Budget 2002 isn't going to support Pluto, then we won't be able to send a probe to Pluto for many years. — *Mykola Kozak, age 15, Ridgewood, New York*

*Congress may also end up telling Dan Goldin how wrong he is regarding a Pluto mission. Although the President's FY 2002 Budget request does not contain funding for a Pluto mission, the issue is not completely dead. In fact, Congress reserved the right to consider a Pluto-Kuiper Belt (PKB) mission in the context of the 2002 budget, and is currently awaiting the results of two three-month concept studies on a PKB mission. If granted approval for development, the PKB mission would launch between 2004 and 2006 and arrive at Pluto before 2020. The decision on this matter is pending as of press time.* — Carol Ryback, associate editor

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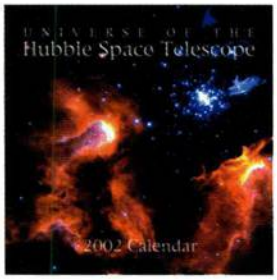
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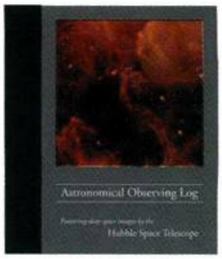
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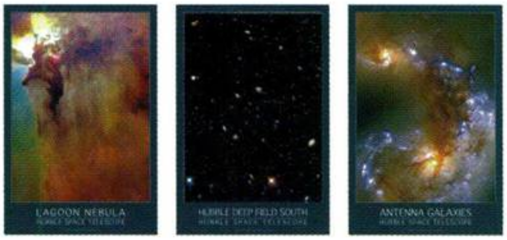
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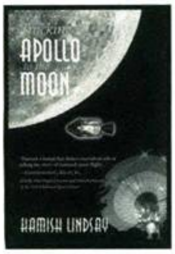

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LIFE ON EARTH

# Scientists Probe Life's Early Days

▶ **Warning:** Reading this article may result in a sudden boyish affectation for foul-smelling gas and slimy bacteria.

According to recently published research from three independent teams of NASA Ames Research Center and Universidad Nacional Autonoma de Mexico astrobiologists, those ingredients, of which little boys are purportedly made, were critical to the development of complex life on Earth two billion years ago. In fact, you might say that we owe our lives to this yucky stuff.

The first signs of complex life began to make their mark on the geological record 2.1 billion years ago. What's more, these fossilized ancestors came shortly after a sudden, and previously unexplained, rise of oxygen in Earth's atmosphere around 2.2 billion years ago.

Today, most of Earth's atmospheric oxygen is a byproduct of photosynthesis — the process by which plants and microbes use sunlight to extract hydrogen from water to manufacture organic materials. But two billion years ago, Earth's atmosphere was nearly void of oxygen.

For decades, scientists have argued about the cause of Earth's sudden oxygen surge. Some researchers proposed seepage from buried reserves of dead organic material. But very few considered the idea that the surge may have been caused by a mass exodus of hydrogen gas into space.

Due to its low atomic weight, hydrogen gas has a greater average velocity at surface temperature than most gases. This allows hydrogen to quite easily escape to space, never to return. Furthermore, oxygen is highly reactive and must be kept away from possible reactants if it is to remain in the atmosphere. Therefore, a rise in oxygen might likely coincide with the depletion of a potential reactant.

One team of researchers, led by Ames scientist Tori Hoehler, reports in the July 10 issue of *Nature* that the answer to hydrogen's mysterious flight can be found in vast microbial populations called mats. Another team, led by Ames colleague David Catling, finds that biological production of methane and other gases may have played a significant role as well.

According to Catling's research, published in the August 3 issue of *Science*, primitive microbe-generated methane gas stole hydrogen from water, leaving excess oxygen behind. As the leftover oxygen saturated Earth's crust, it was eventually released into the atmosphere. What's more, excess methane may have helped make Earth a more hospitable place. "Three billion years ago, the sun was only four-fifths as bright as it is now," says Catling. "The Earth should have frozen over, but methane, a powerful greenhouse gas, would have kept it warm."

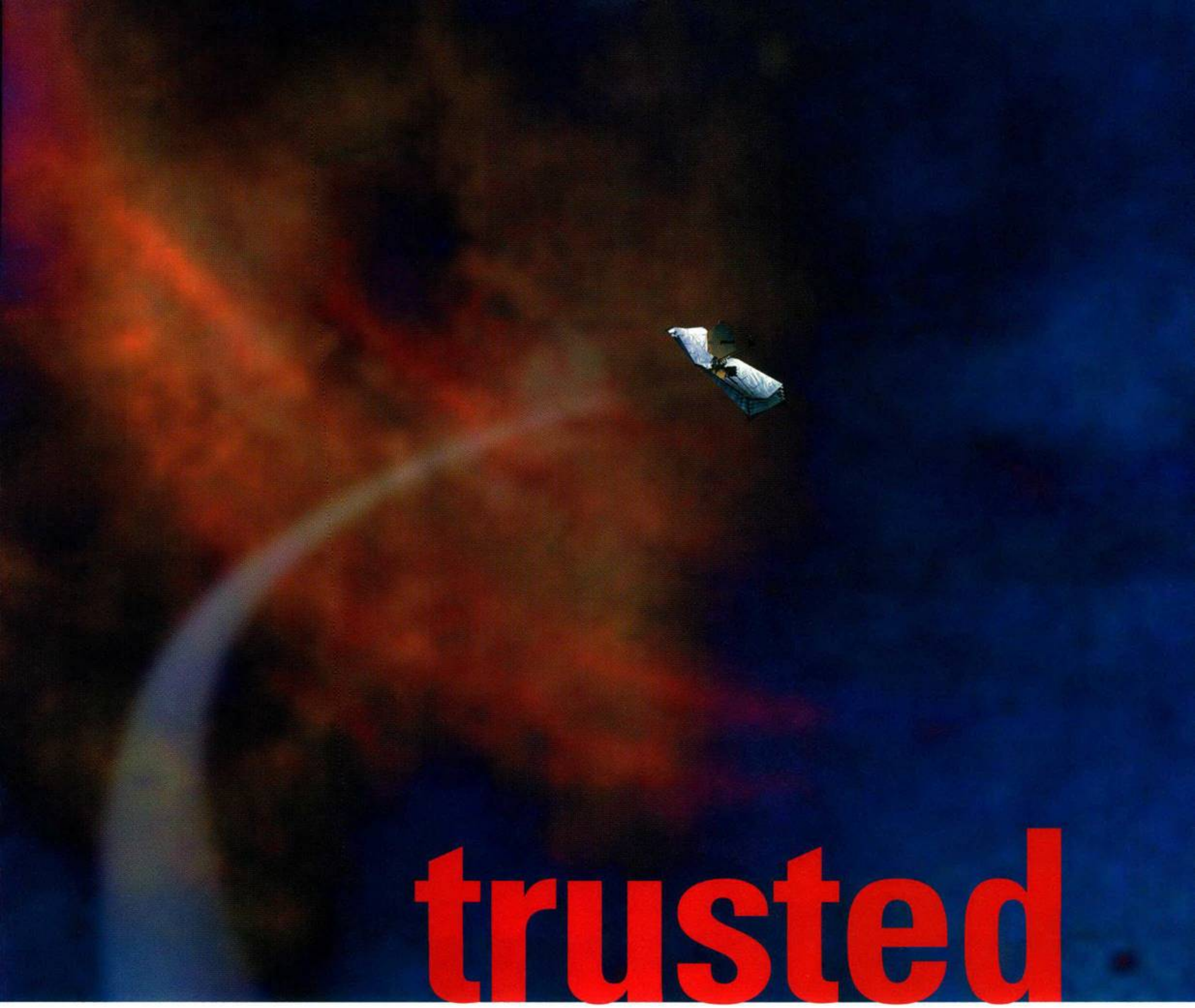
NASA/Ames Research Center

**Tiny bubbles of gas form on the surface of modern microbial mats, harvested near Baja Mexico.**

Looking at modern microbial mats in Baja Mexico, Hoehler and his team found that the gooey critter carpets released large amounts of hydrogen into the atmosphere. "If Earth's early microbial mats acted similarly to the modern ones we studied, they may have pumped a thousand times more hydrogen into the atmosphere than did volcanoes and hydrothermal vents," says Hoehler. The team also found that elevated hydrogen release levels could explain increased methane production, as hydrogen would have provided an important food source for Catling's methane-producing microbes.

In a related study, a team of researchers, led by Ames astrobiologist Chris McKay, finds in their July 5 *Nature* study that life also underwent an evolutionary quantum leap about two billion years ago. Complex life needs nitrogen to survive, particularly nitrate. Early atmospheric nitrate was produced by high-energy lightning bolts that fused atmospheric oxygen, carbon dioxide, and nitrogen. With atmospheric carbon dioxide levels dropping as Earth became less geologically active, so did the rate of lightning-induced nitrate production, providing early earthlings with a dilemma: To find some way of making nitrate on their own, or perish.

McKay and his team believe that it was during this period of low carbon dioxide and low lightning-induced nitrate production (about 100 million years) that life learned how to generate its own nitrogen fertilizer. — WILLIAM SCHOMAKER



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With the largest optical telescope in the world for a looking glass, astronomers have peered deep into the past to see the universe as they never have before. And it's not the universe you might expect. In fact, it's rather dark.

Caltech astronomer S. George Djorgovski and his team reveal, in a report to appear in the *Astrophysical Journal Letters*, that they've finally captured a snapshot of the universe before the formation epoch of quasars and galaxies, when the universe was ruled by a dark, opaque fog.

Djorgovski's team made use of light from one of the most distant quasars known — discovered by the Sloan Digital Sky Survey (SDSS) last year — and the W. M. Keck Observatory's massive Keck II 10-meter telescope atop Mauna Kea, Hawaii, to pinpoint this dark epoch. But far from portending gloom and doom among the ranks, the discovery is good news to cosmologists, who had long predicted this stage in the universe's past.

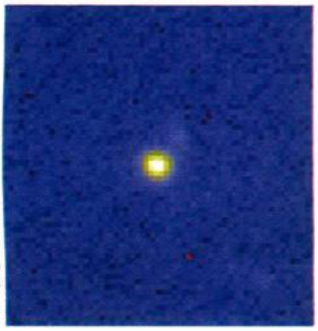
Cosmologists believe that the Big Bang, from which the universe was spawned, occurred about 14 billion years ago. Immediately following the Big Bang, the universe was filled with superheated hydrogen and helium atoms. As these atoms cooled with the expansion of the universe, neutral atoms were eventually able to form — about 300,000 years after the Big Bang. And for the next 500 million years or so, opaque gas ruled the universe, until light from the first quasars and protogalaxies lit up the cosmos and split neutral atoms into protons and electrons to end these so-called dark ages. Astronomers refer to this break-up of the dark era as the reionization era.

Spectra of SDSS 1044-0125 obtained with the Keck II telescope show telltale signs of the dark era. Extended absorption features superposed on the quasar's spectrum were most likely caused by intervening opaque regions along the line of sight between the black-hole-powered quasar and Earth.

From the spectral signature they've gathered, the astronomers believe that they're viewing the last days of the dark ages. "Our data show the trailing end of the reionization era," says Jet Propulsion Laboratory astronomer and team member Daniel Stern. "There were opaque regions in the universe back then, interspersed with bubbles of light and transparent gas." The transition from dark to light may have lasted hundreds of millions of years as light from newly formed quasars and galaxies cleared the fog.

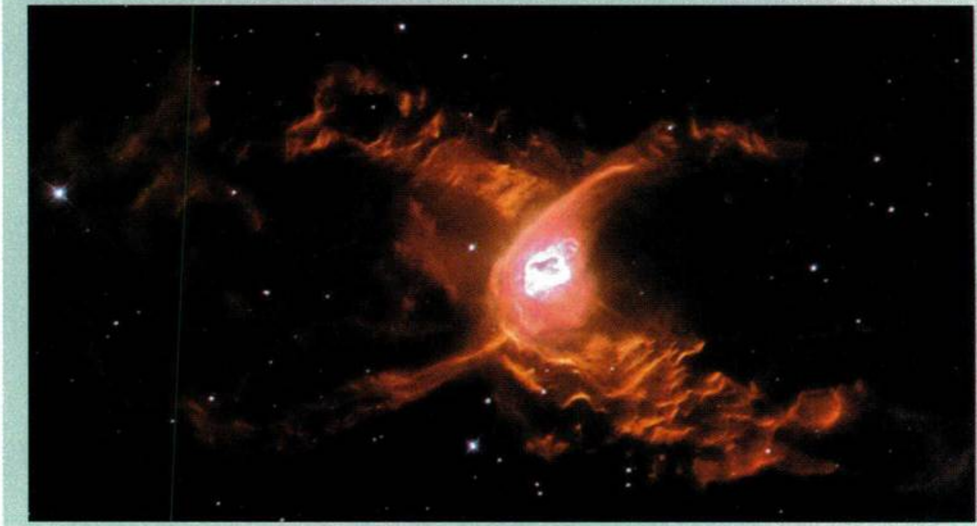
To bolster the impact of their discovery, Djorgovski and his colleagues will continue to investigate more distant and younger quasars. Preliminary reports indicate that several more distant quasars discovered by the SDSS also display this spectral thumbprint of the dark ages. — W. S.

**SDSS 1044-0125 harbors priceless clues about the reionization era, when the universe got lit.**



S.G. Djorgovski, et al., Caltech

HUBBLE SPACE TELESCOPE



ESA/Garrett Mellema (Leiden University)

**WRACKED BY A MASSIVE STELLAR STORM, NGC 6537 (also known as the Red Spider Nebula) redefines the word "extreme." The heart of this berserk bipolar planetary nebula, 3,000 light-years away in Sagittarius, harbors the white-hot 500,000 Kelvin (900,000° F) core of a dead sun-like star. Though the white dwarf itself is invisible to Hubble — being so hot that it emits mostly x rays — its presence is betrayed by catastrophic influence on surrounding gas and dust. The degenerate stellar remnant is, in fact, so hot that blistering winds traveling at 9 million miles (14.5 million km) per hour erupt from its surface and slam into the surrounding nebular material to create enormous waves more than 62 billion miles (100 billion km) high. These waves, traveling at more than half a million miles (1 million km) per hour, make legendary 50-foot (15-meter) surf swells off the shores of Hawaii look like nothing but ripples in a pond.**

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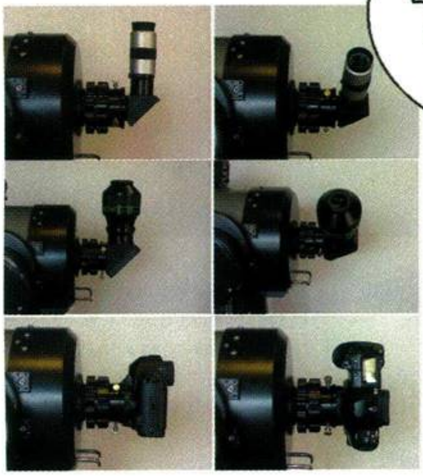

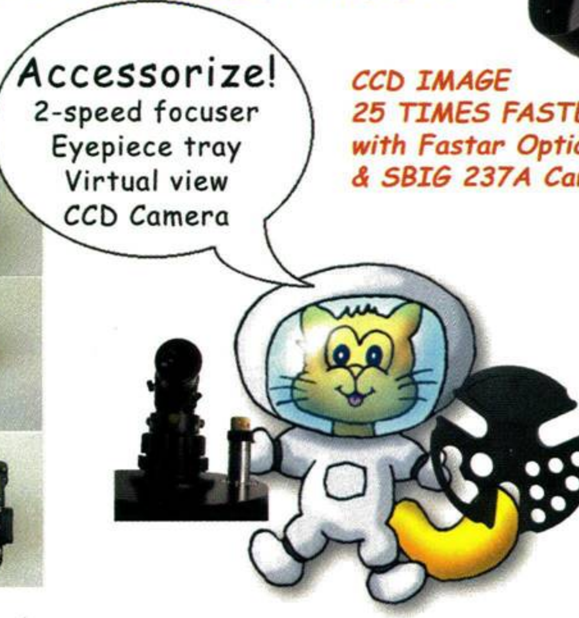
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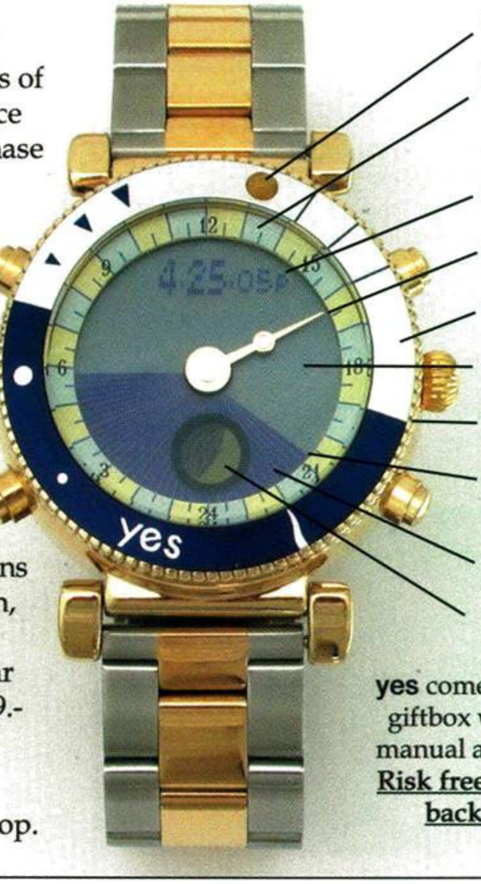
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*STELLAR ASTRONOMY*

# Tightening a Star's Belt

▶ Astronomers have captured the thermal profile of an apparent asteroid belt that rings the nearby star Zeta Leporis (HR 1998) — a finding that fuels the growing notion that solar systems like our own may be an astronomical cliché.

Scientists have yet to actually see individual asteroids orbiting Zeta Leporis. But UCLA graduate student Christine Chen and her advisor, astronomy professor Michael Jura, announced at the summer meeting of the American Astronomical Society that Zeta Leporis is girdled with a swirl of dust in quantities and temperatures suggesting a significant population of space rocks.

Zeta Leporis lies in the constellation Lepus (the Hare) about 70 light-years from our sun. The star is about 100 million years old, a mere infant compared to the sun, which took shape and began to shine roughly 4.5 billion years ago. What Zeta Leporis gives up in age, though, it makes up for in size — it's twice as massive as the sun.

"Zeta Leporis is a relatively young star — approximately the age of our sun when Earth was forming. The system we observed around Zeta Leporis is very similar to what we think occurred in the early years of our own solar system when planets and asteroids were created," says Jura. "Because of the conditions that we identified near Zeta Leporis, we believe that the dust around this star may contain asteroids that appear to be violently colliding with each other."

In the early 1980s, astronomers used the Infrared Astronomy Satellite (IRAS) to detect dust around other hydrogen-burning stars like Vega and Beta Pictoris. Orbiting dust absorbs the optical light cast by the central star and then emits infrared radiation.

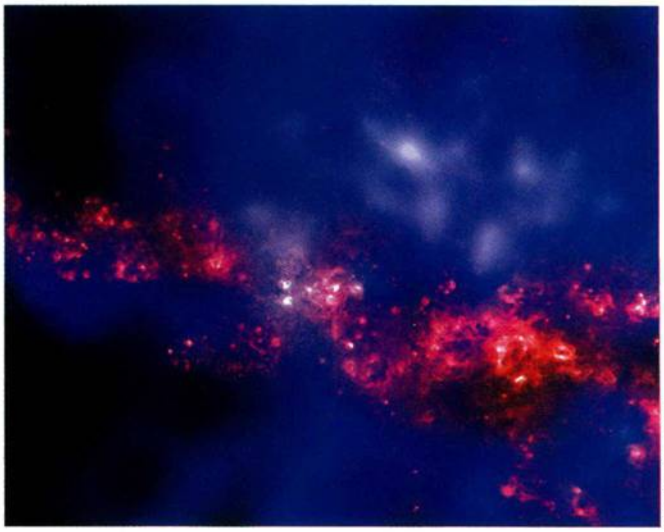
Around the same time, scientists also observed that the infrared radiation aglow from the region of Zeta Leporis was greater than expected — suggesting that the star was wrapped within a cloud of dust and debris.

In February of this year, Chen and Jura probed Zeta Leporis with a long-wavelength spectrometer — an infrared-attuned camera attached to the 10-meter-diameter (33-foot) Keck I telescope on Mauna Kea in Hawaii. The pair found that the dust ring's diameter around Zeta Leporis is no wider than 12.2 AU; 1 AU, or astronomical unit, is the mean distance between the Earth and the sun, or 93 million miles (149 million kilometers). This isn't too far off — in the astronomical order of things — from the 5.4-AU-diameter asteroid belt circling the sun between Mars and Jupiter.

Chen also determined that dust at this orbital distance should only survive about 20,000 years before spiraling into the central star. Because Zeta Leporis is much older than this, there must be some mechanism replenishing the dust, which, she thinks, might be continued collisions between larger space rocks. — PAUL MORLEDGE

**As the Galileo spacecraft flew by 243 Ida in 1993, it snapped several images of the 32-mile wide space rock.**

NASA/JPL



NASA/D. Wang, et al.

**A combined x-ray and optical image of spiral galaxy NGC 4631 nets the first detection of an x-ray halo.**

*X-RAY ASTRONOMY*

# Chandra Spies Whale of a Halo

▶ Recently, five x-ray astronomers, led by Daniel Wang of the University of Massachusetts at Amherst, were elated after their sixteen-and-a-half-hour whale-watching excursion netted nothing but a glimpse at a gigantic mess of hot gas. Last July, Wang and his team pointed NASA's Chandra X-ray Observatory toward the Milky-Way-like spiral galaxy NGC 4631 (also known as the Whale Galaxy) to secure the first detection of its immense x-ray halo.

Combining a long exposure time with Chandra's high-resolution capabilities, Wang's team was able to separate individual x-ray sources from the diffuse halo surrounding the galaxy 25 million light-years from Earth. They plan to use the information they've gathered from NGC 4631 to understand how energy is transported through, and away from, galaxies undergoing star formation, and ultimately to understand how spiral galaxies like the Milky Way evolve.

Astronomers have long believed that spiral galaxies like NGC 4631 and the

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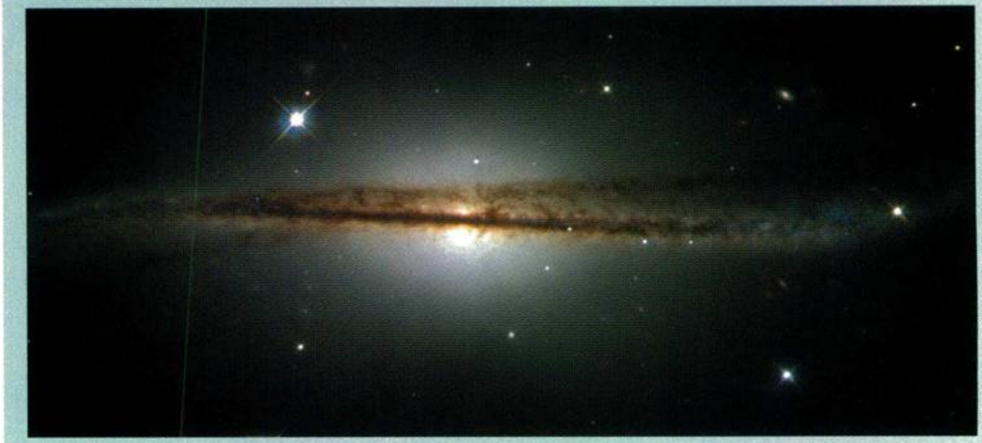
Milky Way Galaxy should possess diffuse x-ray halos, but Wang's observations mark the first unambiguous detection of such a distribution of faint, extended high-energy radiation. The hot gas (three million degrees) rises 25,000 light-years above the disk of NGC 4631. And as a bonus, Wang and his team found that the distribution of the x-ray halo closely resembles that of previously observed radio emission from NGC 4631, telling astronomers that perhaps the same mechanism (coupling to magnetic fields, for example) may be responsible for emission across the electromagnetic spectrum.

To lift gas to heights that rival the distance from Earth to the center of the Milky Way, significant amounts of energy must have been injected into the NGC 4631 system. Recent Hubble Space Telescope studies of NGC 4631 have shown that the x-ray emitting gas also coincides with regions of ongoing star formation. Wang and his team believe that past interactions with neighboring galaxies NGC 4627 and NGC 4656 could have spawned favorable conditions — energy release from supernovae and winds from massive stars — for heating the gas in NGC 4631 to such excessive temperatures, subsequently launching it 25,000 light-years above the disk. — W. S.

**HUBBLE SPACE TELESCOPE**



NASA/Hubble Heritage Team (STScI/AURA)

**LIKE AN OLD RECORD left to bake in the sun, the Milky-Way-like spiral galaxy ESO 510-G13 stands as a testament to the fact that big things like galaxies can warp too. This color-composite Hubble image of ESO 510-G13 shows that it very likely underwent a recent collision and merger with a neighboring galaxy. Bright blue regions near the edge of the galaxy's disk also indicate that collision-induced star formation is taking place as interstellar media from the merging galaxies converge. Astronomers believe that in several million years, ESO 510-G13 will settle down to once again become a normal-looking galaxy. Located roughly 150 million light-years from Earth in the southern constellation Hydra, ESO 510-G13 was last imaged by Hubble in April 2001. By cosmic coincidence, at the same time these images of ESO 510-G13 were taken, the space telescope's workhorse Wide Field and Planetary Camera 2 (WFPC2) passed its 100,000 image milestone, having begun operation in 1993.**

*LUNAR CRATERING*

# Just a Heavenly Coincidence?

▶ After crunching some numbers and leafing through astronomical archives from a variety of cultures, a planetary science graduate student now challenges the popularly held notion that several 12th-century English villagers actually witnessed the explosive lunar collision that blasted out the moon's 14-mile-wide impact crater Giordano Bruno.

The moon's famously pockmarked surface reminds us of its rather violent history of bombardment by crashing asteroids and meteorites. Most lunar craters are millions to billions of years old, carved out by impacts from meteorites and pieces of comets and asteroids. But the crater Giordano Bruno — named for the 16th-century Italian monk and philosopher who held some heretical views about the universe and was subsequently burned at the stake during the Spanish Inquisition — shows all the signs of being astronomically recent.

"Based on its extensive pattern of bright rays and unerroded morphology, Giordano Bruno is the youngest lunar crater of its size," says Paul Withers, a graduate student in the University of Arizona's Department of Lunar and Planetary Science.

Because of the crater's apparent youthfulness, it became popular a few years back for astronomers to speculate on how old it really was. In 1976, planetary geologist Jack Hartung formulated what has since been known as Hartung's Hypothesis, claiming that the formation of the Giordano Bruno crater was witnessed and recorded on June 18, 1178.

The event, thought Hartung, was described in a passage from the medieval

**Though a young lunar crater, Giordono Bruno doesn't appear to be of 12th-century vintage.**

NASA/DoD

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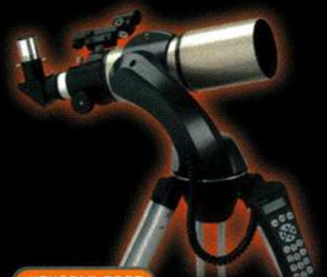

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chronicles of Gervase of Canterbury (a monk and medieval version of reporter), who spoke of five eyewitnesses who beheld the crescent moon "suddenly split in two. From the midpoint of this division a flaming torch sprang up, spewing out fire, hot coals and sparks."

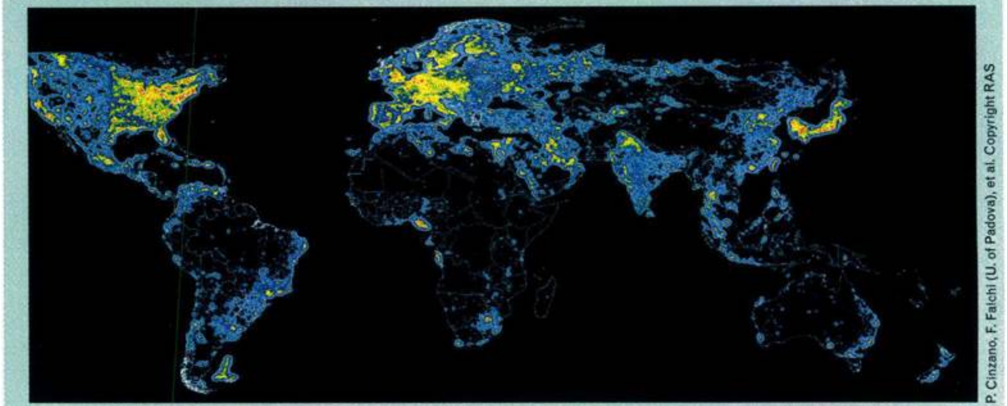
Withers thinks that the one-to two-mile-wide asteroid that created Giordano Bruno would have produced more of a spectacle. In fact, he estimates that about a week after this lunar impact, nearly 10 million tons of lunar ejecta would have showered down on Earth at a rate of 50,000 meteors per hour.

"I calculate that this would have caused a week-long meteor storm potentially comparable to the peak of the 1966 Leonids storm," says Withers. "And they would have been very bright, very easy to see, at magnitude 1 or magnitude 2. It would have been a spectacular sight to see. Everyone around the world would have had the opportunity to see the best fireworks show in history."

Yet, according to Withers, no historical accounts of such a spectacular sky event exist. He searched far and wide through European, Chinese, Arabic, Japanese, and Korean astronomical archives, but came across nothing.

Withers thinks a heavenly coincidence of sorts, perhaps a bright meteor that passed fleetingly in front of the moon at just the right moment, is probably to blame for the erroneous reports. "If you were in the right [spot] on Earth's surface, you'd get the perfect geometry," explains Withers. — P. M.

## LIGHT POLLUTION



P. Cinzano, F. Falchi (U. of Padova), et al. Copyright RAS

**THE NIGHT SKY GROWS BRIGHTER by leaps and bounds every year. And now, for the first time, scientists can place hard numbers on the growing problem of light pollution. Research carried out by scientists with the University of Padua, Italy and the NOAA National Geophysical Data Center in Colorado, reveals that two-thirds of the people in the world and 99 percent of people in the continental United States and western Europe never see a truly dark, starry sky because of light pollution.**

**From the data, the team has created the first global light pollution atlas. Blue areas on the map above define light-polluted sky, highlighting areas where brightness from artificial light exceeds natural sky brightness by 10 percent. Red areas indicate zones where less than 100 stars are visible over 30 degrees of elevation. Yellow marks regions where artificial sky brightness exceeds natural sky brightness by 100 percent. The Milky Way isn't visible to the naked eye from those areas marked in orange.**

*X-RAY ASTRONOMY*

# Milky Way Mystery Solved

▶ An international team of astronomers has recently probed the far side of the Milky Way Galaxy to secure the answer to one of x-ray astronomy's most nagging mysteries: the origin and nature of x-ray emission from the galaxy's plane.

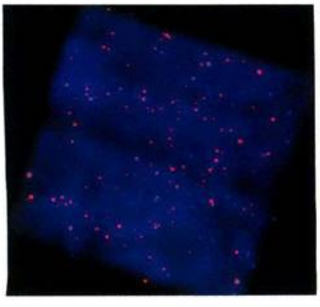
Since the rise of x-ray telescope technology in 1962, astronomers have wondered whether the pervasive high-energy galactic radiation is being emitted from hot, diffuse gas or from unresolved x-ray point sources. Now, with the help of NASA's Chandra X-Ray Observatory, Goddard Space Flight Center astronomer Ken Ebisawa and his team are confident that hot, diffuse gas is the culprit.

In the thick of the Milky Way's disk, which spans a diameter of about 100,000 light-years, roughly 25,000 light-years separate Earth from the center. For 28 hours last February, Ebisawa and his colleagues kept Chandra pointed through the galactic disk toward a tiny patch of sky in the constellation Scutum.

In a paper published in the August 10 issue of *Science*, they report that the target region — classified as an x-ray hole previously known to be devoid of individual x-ray sources — contained 36 undiscovered galaxies millions of light-years beyond the Milky Way. Still, they discovered very few additional point sources residing in the galaxy. Ebisawa and his team argue that such diffuse x-ray emission implies that the galactic plane is polluted with a hot plasma approaching ten million degrees or more.

But the solution of one Milky Way mystery has spawned another: If hot, diffuse gas is responsible for the planar x-ray emission, why hasn't the gas expanded to escape the confines of the plane? Ebisawa thinks that confinement from magnetic fields might play a role in

**Red dots represent foreground objects, while blue dots mark galaxies beyond the Milky Way.**



NASA/CSFC/K. Ebisawa,et al.

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answering that question. Ultimately, it will take further investigation to solve this riddle too.

Ebisawa also hopes that one day astronomers will be able to use the galaxies they've discovered to probe the condition and distribution of material in the Milky Way. Because their light travels through the majority of material in the galaxy, these bright beacons carry information from all intervening galactic material it passes through. — W. S.

*GLOBULAR CLUSTERS*

# Mystery Objects Wander M22

▶ Using the Hubble Space Telescope (HST) to monitor the brightness of 83,000 stars in the Milky Way Galaxy's halo, an international team of astronomers, led by Space Telescope Science Institute astronomer Kailash Sahu, recently discovered a half dozen low-mass objects lurking in M22 — a well-known galactic globular cluster and favorite deep-sky target among amateur astronomers.

**Hubble pierced the heart of M22 to find a strange and unexpected population of low-mass objects.**

NASA/ESA/K. Sahu (STScI)

Each of the objects (believed to have masses roughly 80 times that of Earth) was found with an observational technique based on the gravitational deflection of starlight. Such gravitational "microlensing" searches operate under the premise that the brightness of a background star momentarily increases as a foreground object drifts by the line of sight. Many microlensing events caused by stellar-mass foreground lenses have been observed, but never from such low-mass foreground lenses as those spied by Sahu's team.

The HST's high-resolution capabilities and narrow field of view allowed Sahu's team to probe the interior of M22, using stars from the Milky Way's bulge as a microlensing backdrop. Each of the low-mass lens objects caused background bulge stars to brighten by a factor of two for approximately 20 hours. This stands in stark contrast to the lensing signature caused by stellar mass objects, which may bring a tenfold brightness increase that lasts for days.

As the lensing objects are known to belong to the cluster, Sahu and his team are confident that they lie 8,500 light-years from Earth. Still, the nature and origin of these wandering widgets remains unknown. Could they be planets torn from their parent stars, or leftover bits from the star formation process? Once again, the debate over what makes a planet a *bona fide* planet has been sparked.

Sahu and his colleagues caution that follow-up observations will be necessary to confirm the existence of their astronomical whatchamacallits. — W.S.

## Genesis to Retrieve Pieces of Sun

Keeping with their tradition of daring to deliver the impossible, NASA now promises to capture the wind — the solar wind, no less. If all goes according to plan, the Genesis spacecraft, which experienced a picture-perfect launch on August 8, 2001, will become the first space mission to deliver extraterrestrial material from beyond the moon. The craft is scheduled to arrive at its observation point between Earth and the sun this fall, where it will collect ions flowing from the sun. In September 2004, Genesis and its 10-to-20-microgram payload will return to Earth and be airlifted to Johnson Space Center in Houston, Texas, for storage and analysis.

NASA

**Nestled atop a Boeing Delta II rocket, Genesis heads for the wind.**

## Time Is on Our Side

The world's most accurate atomic clocks, based on the natural pendulum-like resonances of the cesium atom, won't gain or lose a second in 20 million years. If that's not good enough for you, National Institute of Standards and Technology researchers have just unveiled a new atomic clock based on a single trapped mercury ion that promises to be 1,000 times more accurate than its predecessors. Because operation of the mercury ion clock demands capturing the ion, holding it still to make accurate measurements, and equipment capable of counting one quadrillion cycles per second, ticker technology needed to catch up with the theoretical design. And the time, as they say, has finally come.

## Astronomer Who Coined "Big Bang" Dies

Renowned British astronomer Sir Fred Hoyle died at his home in Bournemouth, England, on August 20 at the age of 86. Hoyle was perhaps best known as a staunch proponent of the steady state theory of cosmology, which he developed along with Hermann Bondi and Thomas Gold in the 1940s. Ironically, he's also credited for derisively coining the phrase "Big Bang" during a BBC radio broadcast in 1950 to describe the then-burgeoning theory of the origin of the universe. Though the Big Bang theory has held steady for more than 50 years, Hoyle never subscribed to it. Hoyle, who graduated from Cambridge University, was an astronomy professor there from 1958 until 1972. Throughout his working career, he held staff positions at Mt. Wilson and Palomar Mountain Observatories and wrote several science fiction stories, including *The Black Cloud* (1957). He is survived by his wife, a son, and a daughter.

# The Biggest Thing To Hit Astronomy Since The Bang.

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*Freight charges may apply*

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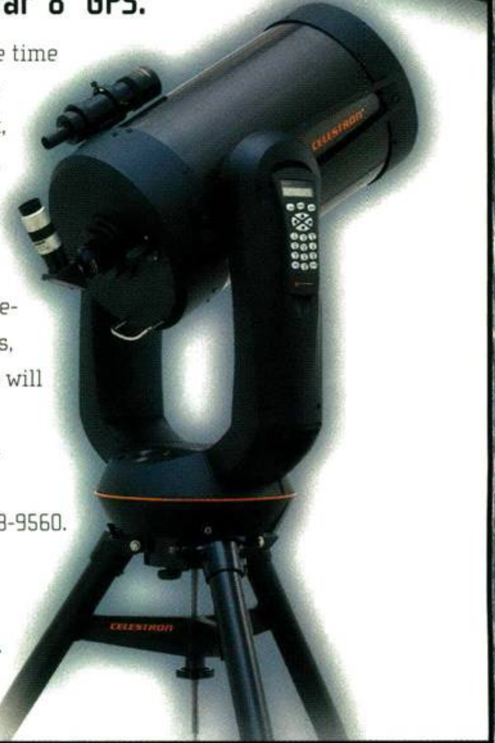

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### SOFTWARE:

- 40,000+ object database. Stores numerous user-defined objects.

### ELECTRONICS:

- Computerized hand control with easy-to-read backlit liquid crystal display (LCD) unit
- Permanent Periodic Error Correction (PPEC) – once periodic errors are recorded for elimination, the telescope maintains the recording even when turned off and on
- Built-in, adjustable backlash compensation
- AutoGuider Port
- Port for 12V DC power output
- Fastar compatible for f/2 CCD Imaging

- RS-232 port for communication with a PC to operate and use with the telescope (one on hand control and one on base drive)
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### MECHANICAL

- Dual die-cast aluminum fork tines
- Large 9.5" roller bearing track for an ultra-stable polar axis
- 5.625", 180-tooth gears with precision worms for accurate tracking
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- Less than one second

### OPTICS

- NexStar 8 GPS 8" (203.2mm) large aperture Schmidt-Cassegrain optical system
- Focal length of 2032mm at f/10
- Resolution: .57 arc seconds
- NexStar 11 GPS 11" (279mm) large aperture Schmidt-Cassegrain optical system
- Focal length of 2800mm at f/10
- Resolution: .41 arc seconds

### WEIGHT

- NexStar 8 GPS only 42 pounds
- NexStar 11 GPS only 65 pounds
- Tripod weighs only 26 pounds

### STANDARD ACCESSORIES

| nexstar 8 gps | nexstar 11 gps |
|---|---|
| 40mm multi-coated 1.25" Plössl eyepiece (51X)<br>9x50 Finderscope<br>AC adapter<br>1.25" star diagonal<br>Heavy duty tripod | 40mm multi-coated 1.25" Plössl eyepiece (70x)<br>9x50 Finderscope<br>AC adapter<br>Carbon Fiber Tube<br>1.25" star diagonal<br>Heavy duty tripod |

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**"Tour The Universe" Trip from Star Safaris**

One lucky winner and three guests will spend 4 days and 3 nights skiing and stargazing at their choice of destination – either Kirkwood, Durango, Lake Powell, Squaw Valley, or Grand Canyon Resort. Trip includes hotel, round-trip airfare, two-day lift tickets, and ski rentals for four people.

**OR WIN ONE OF 31 OTHER PRIZES!**

MEADE LX90 EMC
MEADE

**MEADE**

**First Prize– 1 awarded: Meade LX90 Telescope**

**ORION TELESCOPES & BINOCULARS**

**SecondPrize– 1 awarded: Orion SkyQuest XT10 Dobsonian Reflector**

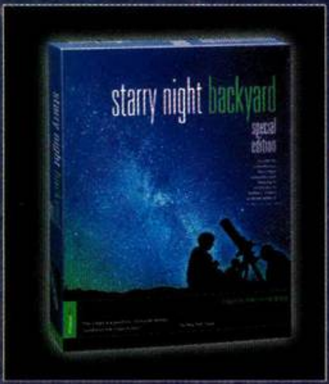
Background photo by Ed Barnes

A38672ad

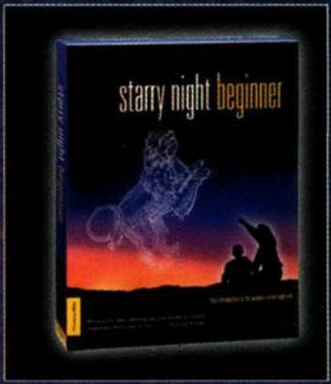
# HURRY!
# ENTER BEFORE
# JANUARY 15, 2002

starry night pro

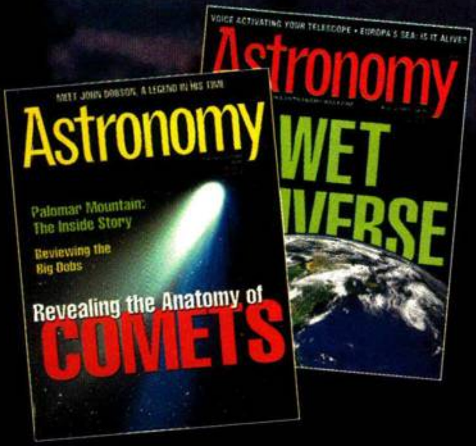
**Third Prize–**
**3 awarded:**
**Starry Night**
**Pro Software**



**Fourth Prize–**
**3 awarded:**
**Starry Night**
**Backyard**
**Software**



**Sixth Prize–**
**3 awarded:**
**Starry Night**
**Beginner**
**Software**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1. No Purchase Necessary. Official entry forms are bound in *Explore the Universe 2002* and the November 2001, December 2001, and January 2002 issues of *Astronomy*. *Astronomy's* Tour the Universe Sweepstakes is open to residents of the United States and Canada (except Quebec) only, 18 years of age or older. Employees (and their dependents and immediate household members) of Kalmbach Publishing Co., their advertising and promotional agencies, and sponsoring companies are not eligible to participate.

2. Sweepstakes Entry. To enter, complete and mail the official entry form or a postcard with name, address, city, state or province, zip, and telephone number to: *Astronomy*'s Tour the Universe Sweepstakes, P.O. Box 378, Waukesha, WI 53187-0378. Or, enter online at astronomy.com by filling in the Online Entry Form and hitting the SEND key. The Online Entry Form must be filled out completely to be eligible. Incomplete or defaced entry forms are void. One entry per household. The official ending date for the *Astronomy*'s Tour the Universe Sweepstakes will be January 15, 2002, and all entries must be transmitted or postmarked no later than that date.

3. Prizes and Odds of Winning. One drawing will be held on or about February 4, 2002, for the following awards: One Grand Prize consisting of a four day, three night trip for four on the Star Safaris "Tour of the Universe" program. Includes round trip coach airfare, the winner's choice of accommodations at either the Kirkwood, Durango, Lake Powell, Squaw Valley or Grand Canyon resort (dual occupancy), two day lift tickets and ski rentals, but will not include ground transportation, beverages, tax, tips, meals and any other expenses (estimated retail value $4,100.00). Winners must travel between May 1, 2002 and September 30, 2002. Travel arrangements must be made 60 days prior to departure date. Star Safaris reserves the right to change the venue. One First Prize consisting of a Meade LX90 telescope (retail value $1,695.00). One Second Prize consisting of an Orion SkyQuest XT10 Dobsonian Reflector (retail value $769.00). Three Third Prizes consisting of the Starry Night Pro software (retail value $129.95). Three Fourth Prizes consisting of the Starry Night Backyard software (retail value $59.95). Twenty Fifth Prizes consisting of a one-year subscription to *Astronomy* Magazine (retail value $39.95). Three Sixth Prizes consisting of the Starry Night Beginner software (retail value $29.95). Cash equivalents of merchandise and/or travel prizes will not be awarded. Substituting prizes is not allowed. Any applicable federal, state, and/or local taxes are the responsibility of the winner. Odds of winning depend on the number of entries received. Total circulation for *Astronomy* is 171,497, and total circulation for *Explore the Universe* 2001 is 72,000. Sweepstakes void in Quebec and void where prohibited.

4. Validation and Acceptance. Winners in *Astronomy*'s Tour the Universe Sweepstakes will be selected in a random drawing conducted by an independent judging organization whose decisions are final. Canadian prize awards subject to skill test requirement. By entering the sweepstakes, participants agree to be bound by these official rules and all decisions of the judging organization. Sweepstakes entries void if not legible, not completed in full, not obtained legitimately, or if forged, photocopied, mechanically reproduced, late or tampered with. The potential winners must sign and return an Affidavit of Eligibility, publicity release and Release of Liability within fourteen (14) days of notification. Winners will be required to designate a travel companion, who must complete an Affidavit of Eligibility, publicity release, and Release of Liability. In the event of non-compliance, alternate winners will be randomly drawn. No responsibility is assumed for lost, stolen, misdirected or late entries or notifications. All sweepstakes entries become the property of the sponsor and will not be returned.

5. Winner's List. For a list of winners, send a stamped, self-addressed envelope to: *Astronomy*'s Tour the Universe Sweepstakes Winners List, P.O. Box 1612, Waukesha, WI 53187-1612. Residents of FL, VT, and WA may omit stamp. Requests must be received by April 4, 2002. Or check the *Astronomy* web site (www.astronomy.com) after June 4, 2002.

6. Kalmbach Publishing Co. shall not be liable for any injury, loss, damage, cost, or expense arising, directly or indirectly, in connection with sweepstakes and the prize awarded.

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A compact, grab-it-and-go Maksutov-Cassegrain telescope that is a great value for beginners. The StarMax 90 provides a whole new level of versatility, visual clarity, portability and convenience.
*A 90mm Maksutov-Cassegrain design, 1250mm focal length (f/13.9), with 6x20 cor-rect-image finder scope, 25mm Sirius Plössl eyepiece (1.25"), 90° mir-ror star diagonal, soft carrying case, and sturdy EQ-1 mount.*

**$299**

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The overachieving XT6 will show Jupiter's Red Spot, Saturn's Cassini Division, hundreds of clusters and nebulas, and galaxies tens of millions of light-years distant. Nicely portable and very affordable!
*Steel tube, 152mm parabolic mirror (f.l. 1200mm, f/8), 1.25" aluminum R&P focuser, 6x30 achromatic finder scope, 25mm (48x) and 9mm (133x) Plössl eyepieces (1.25"), Moon filter, eyepiece rack, 5" flanged altitude hubs, CorrecTension Friction Optimization, dust cap. Weight: tube 13 lbs., base 24 lbs.*

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VX102-FL Tube Assembly
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|---|---|---|
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| **11x70** | 4.5° field | **$269** |
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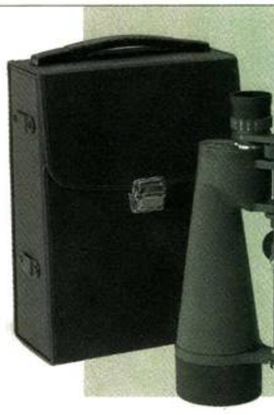

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*20mm Sirius Pl˜ssl eyepiece, 12.5mm Sirius Plössl eyepiece, Moon Filter, DeepMap 600 folding star chart, RedBeam LED astro flashlight, aluminum accessory case.*

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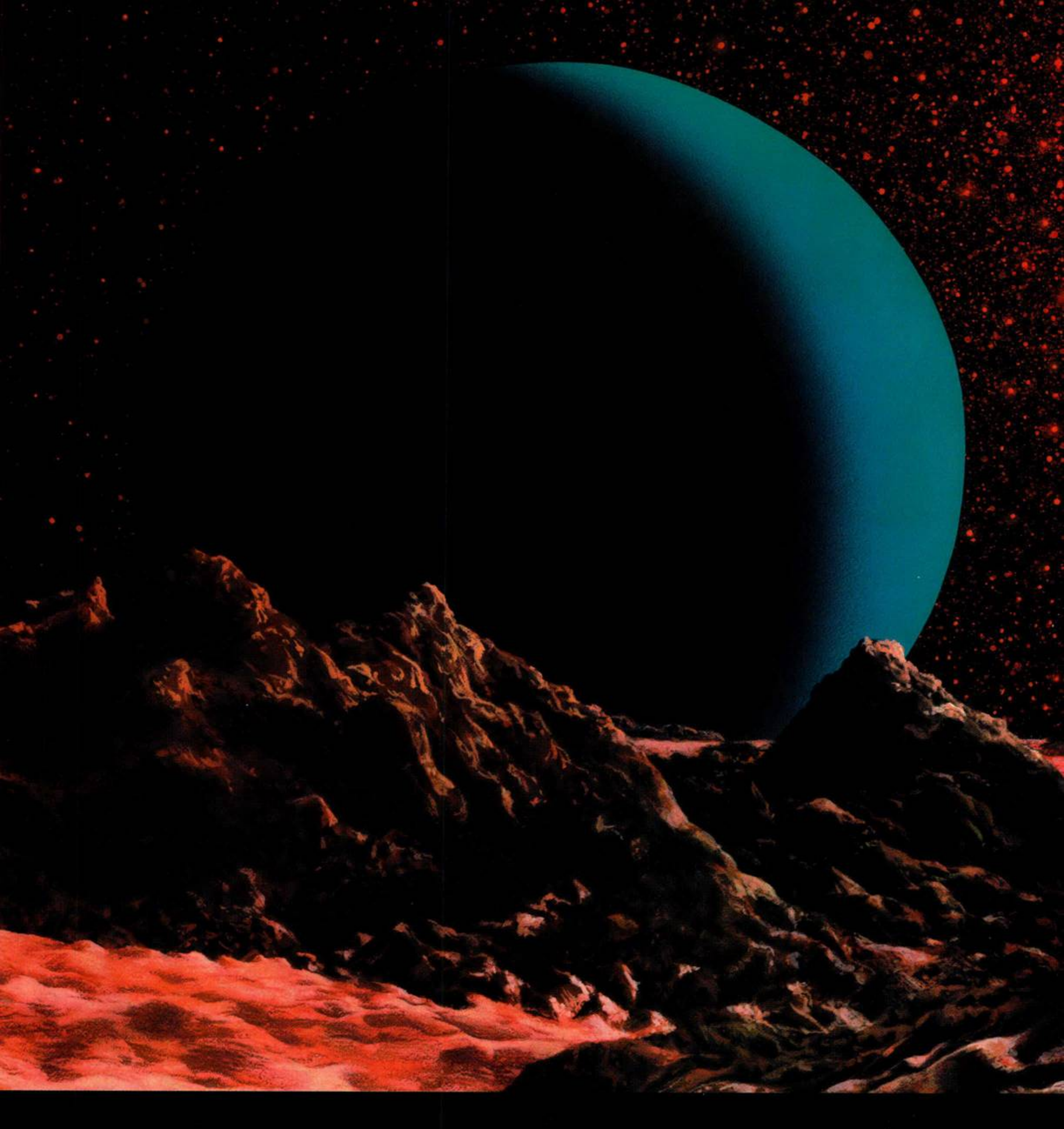
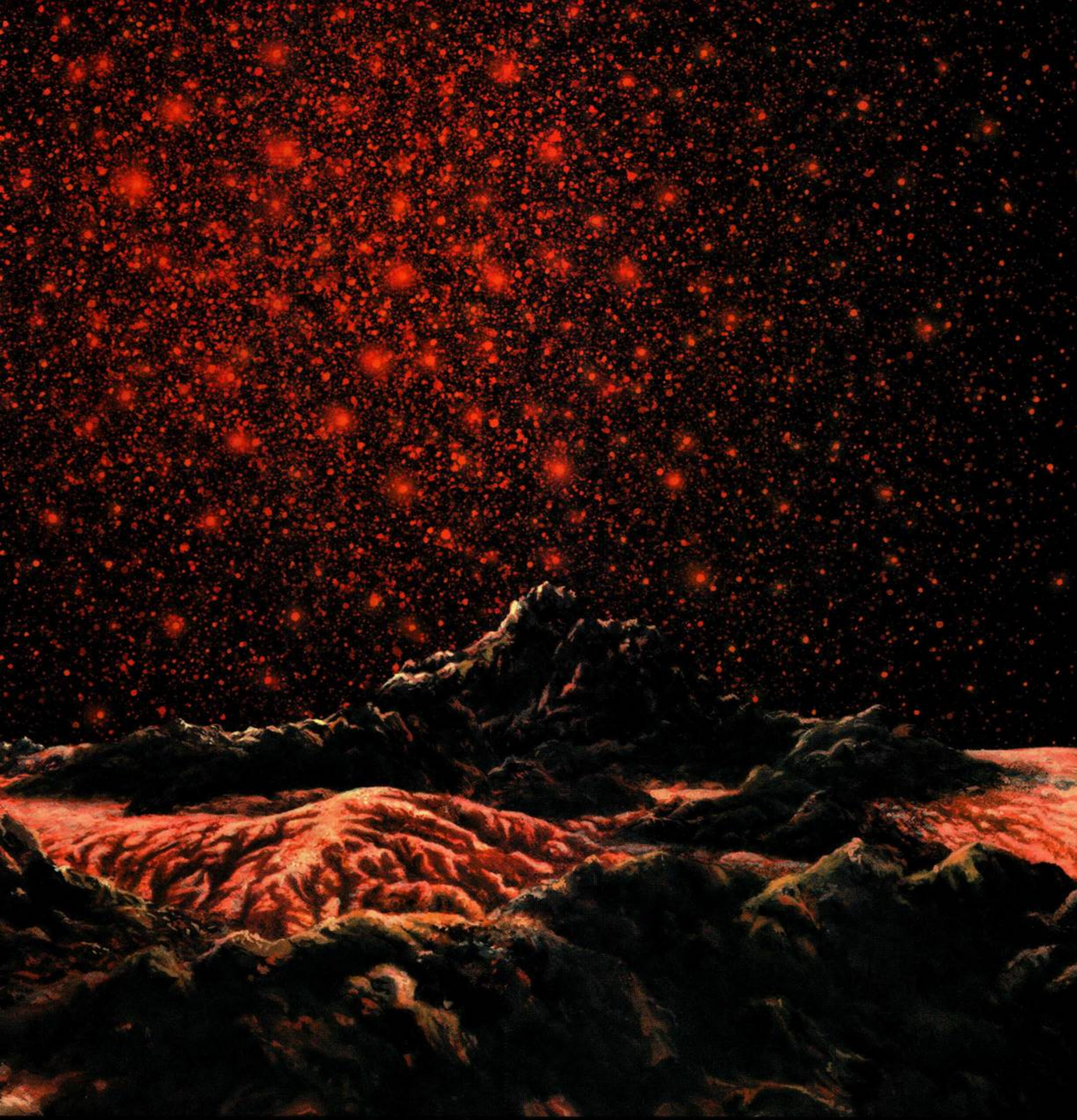


# CELEBRATING THE

One hundred billion years from now, the Milky Way Galaxy will be a



# GALACTIC MILLENNIUM

vastly different place. Text by Greg Laughlin and Fred Adams • Paintings by Lynette Cook

**Previous spread: One hundred billion years from now a dying galaxy of red stars surrounds the remnants of our solar system. Seen from the surface of Io, Jupiter now appears a featureless blue-green.**

The fireworks have ended; the champagne has run dry. Whether you followed the popular swell in January 2000, or adhered to the purist definition and popped the corks in January 2001, the turning of the millennium has come and gone. If we adopt an astronomical perspective, however, a much larger and more distant celebration remains on the schedule — the Galactic Millennium. Just as Earth and the other planets orbit the sun, the solar system orbits the center of the Milky Way Galaxy. What will the solar system, the galaxy, and the universe look like when enough time has elapsed for the sun to make a thousand circuits around the Milky Way? How will the galaxy evolve over this enormous stretch of time? Although it is reasonably likely that we — the human race — won't be around to witness the ball drop, it is hard to resist speculation into the millennial future.

AS THE MILLENNIUM WEARS ON, THE GALACTIC INVENTORY OF GLOWING STAR-FORMING REGIONS WILL SLOWLY FADE TO BLACK.

The present-day galaxy is relentlessly empty and spans a tremendous scope. If we engage in a mind-bending leap and shrink the sun to the size of a sand grain, however, the galactic scale becomes more tractable. In a scale model where stars are the size of sand grains, the nearest stellar system (Alpha and Proxima Centauri) is six miles away. Our galaxy contains roughly 100 billion stars. If sand grains are packed tightly together, then 100 billion of them fit comfortably into a duffel bag.

In a scale model of the galaxy, the sand-grain stars are spread out through an enormous disk several thousand miles thick with a diameter roughly the size of the moon's orbit around Earth. In this model, the stars crawl through their orbits at a painfully glacial pace of a few feet per terrestrial year. The galactic year is thus quite long by human, or even geological, standards. The sun takes nearly 100 million terrestrial years to make a full circuit of the galaxy. The last time the sun passed through our current galactic longitude was in the middle of the Cretaceous period. The giant continent Gondwanaland was beginning to break up into Africa and South America. In this era before the reign of *T. Rex*, the giant *Carnotaurus* enjoyed its place at the top of the food chain.

Our middle-aged Earth is now in its 46th galactic year, and the galaxy is between 100 and 150 galactic years old. The celebration of the Galactic Millennium, when the universe is 100 billion years old, will be witnessed by a chaotic jumble of aging stars bearing little resemblance to the present-day galaxy. The delicate spiral structure will be gone. The enormous giant molecular clouds, ripe with hot young stars, will be a distant memory. Earth will be a frozen cinder, and the sun will be a frigid sphere of degenerate carbon. And a mere 6 billion years from now, a trio of enormous events will occur as the sun becomes an elderly red giant star, the Andromeda Galaxy and the Milky Way collide and merge, and a wave of star formation blasts through what becomes of our home galaxy.

## Greenhouse Earth

In ten galactic years — a billion terrestrial years from now — the galaxy will look much like it does now. The fine grain of detail, however, will be quite different. As the sun executes its next ten circuits around our galaxy's central hub, the familiar constellations will be scrambled one hundred times over. The bright stars currently in our night sky will come to unhappy ends. Deneb and Rigel, for example, will explode as supernovae in the relatively near future. Sirius will swell into a red giant, puff out a planetary nebula, and then settle down with its white dwarf companion as an inconspicuous pair of degenerates (quantum mechanical degeneracy, that is). All three stars in the Alpha Centauri system will still be shining steadily, but not in our skies. Although Alpha Centauri is currently the sun's closest neighbor, it lies on a distinctly different galactic orbit. Over the next million years it will recede from the sun, and its apparent brightness will fade below the threshold of naked-eye visibility.

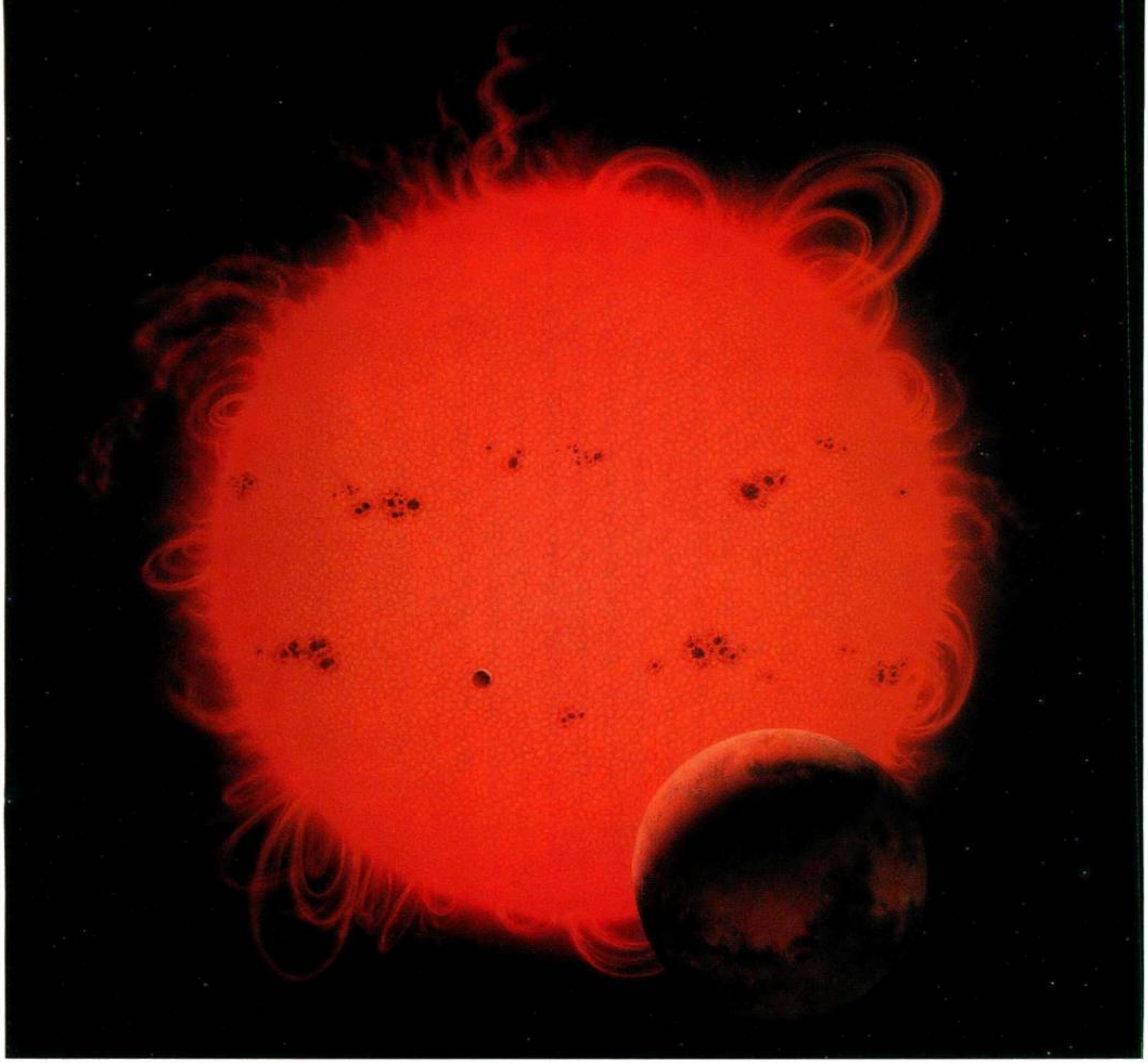
As the next billion years unfold, Earth will face more pressing problems than renaming battered constellations. To date, the sun has fused approximately half of its central store of hydrogen into helium. As inert helium ash accumulates in the solar core, the efficiency of nuclear processes steadily decreases, and gravity impels the center of the sun to contract and heat up. Contraction and heating in the solar center raise the overall power output at the surface. As a result, in ten galactic years the sun will be 10 percent brighter than it is today. This increase in the sun's luminosity will induce unwelcome weather on our planet. Cloud-free global climate models indicate that Earth may experience a steamy "moist greenhouse" effect within a billion years. The scalding surface temperatures would create a catastrophic effect on the surface biosphere. In 3.5 billion years, the sun will be 40 percent brighter than it is now. Earth will lose its water and presumably its entire burden of life, and wind up as a twin of the planet Venus.

## The Sun Becomes a Red Giant

According to computer models of stellar evolution, the hydrogen fuel in the sun's central core will be exhausted in 6.2 billion years. At this time, the sun will be 2.2 times brighter than it is now, and Mars will be receiving roughly the same flux of illumination that Earth currently enjoys.

The exhaustion of its central hydrogen will mark the end of our sun's stately 11-billion-year stint as a main sequence star. To support itself against the inexorable attraction of its gravity, the sun needs internal pressure. During main-sequence life, the requisite central pressure is maintained by hydrogen fusion. After the hydrogen fuel is exhausted, energy will leak out of the sun, and the pure helium core remaining at the center of the sun will be unable to support the crushing weight of the layers above. The core will be forced to contract and heat up.

This extra heat will cause the thinner outer layers of the sun to swell, and the sun will be launched into a 700-million-year career as a red giant. The red giant sun will wreak havoc



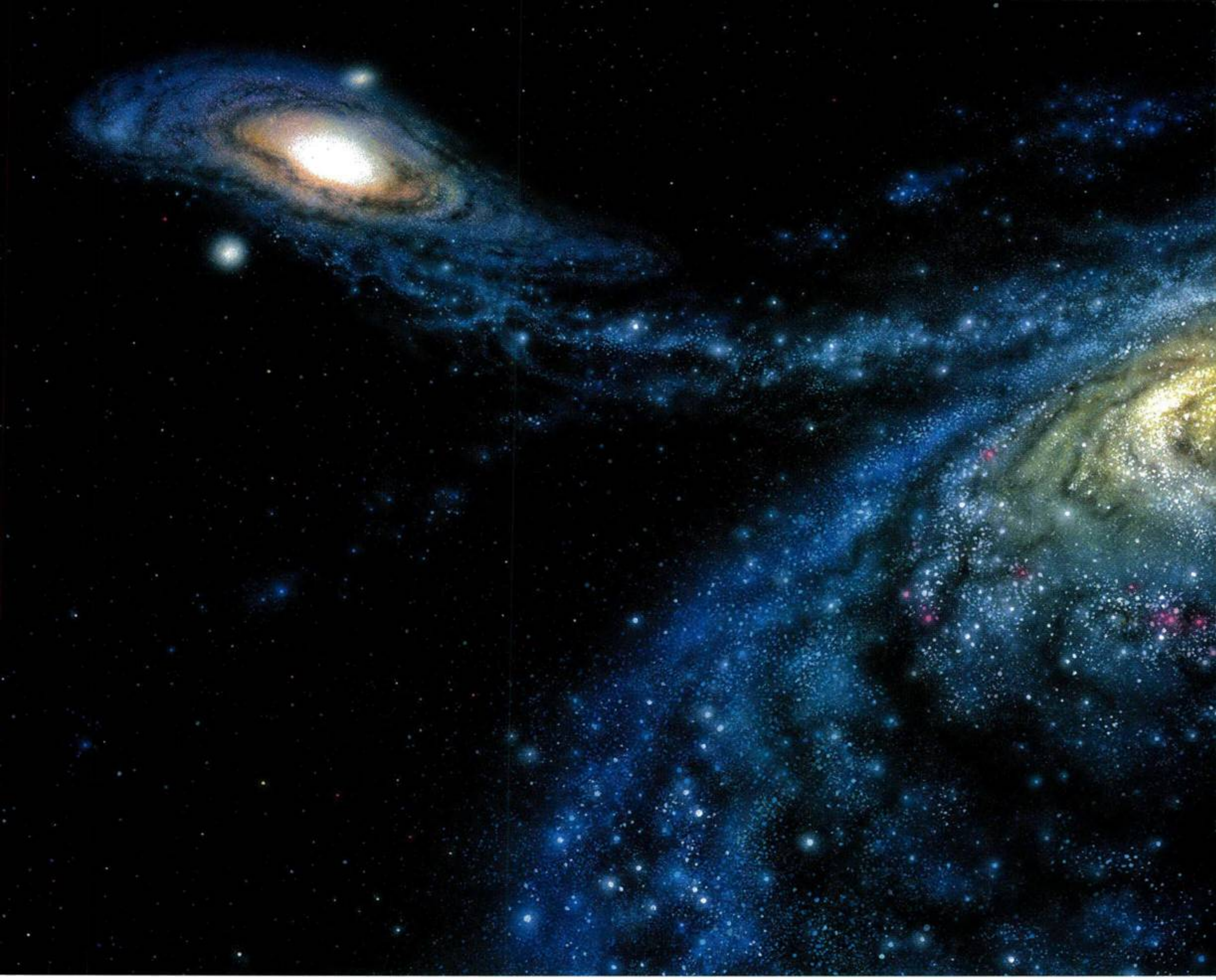
on the solar system. Mercury, and possibly Venus, will be engulfed and vaporized by the sun's outer layers. The rocky surface of Earth will melt. Even Pluto and the other icy objects in the Kuiper Belt will eventually warm above the freezing point. At its brightest, the sun will shine with 5,000 times its current luminosity, and its radius will swell to 1 astronomical unit (AU), as wide as the present Earth-sun distance. During its red giant phases, the sun will lose 45 percent of its mass to a strong outflowing wind. This mass loss will cause the orbits of the surviving planets to expand. Eventually, the sun will eject its outer layers as a planetary nebula, and a 0.55-solar-mass white dwarf remnant will be exposed.

The reincarnated white dwarf sun will exert less of a gravitational pull on the remaining planets. Earth's final orbit will enlarge to 1.7 AU, and every terrestrial year will drag on for 1,100 days. With a smaller sun, the planets will exert larger gravitational effects on each other. Many asteroids, especially those near the inner edge of the main asteroid belt, will find themselves in unstable orbits. They will either crash into a planet or be ejected into interstellar space. The prognosis for Pluto appears lonely; simulations indicate that it will be ejected within a few billion years of the sun's demise.

**In some 6 billion years, the sun will swell into a red giant, completing its baking of the inner solar system. Long before this point life on Earth will have become untenable; at this stage, the sun's radius will expand outward toward Mars, and Earth, visible as a disk that resembles a sunspot, will be completely fried.**

## Toward a Golden Age of Planets

The galaxy acts as the ultimate recycling bin. When stars end their main sequence lives and die — either quietly by ejecting a planetary nebula, or violently through a supernova explosion — they return some of their mass back to the interstellar medium. This recycled material is enriched in heavy elements created by nuclear fusion, and each generation of stars is richer in heavy elements than its predecessor. The recycling process is not terribly efficient, however. High-mass stars are the most conscientious citizens and return most of their material to interstellar space. An eight-solar-mass star, for example, returns more than 80 percent of its mass to the interstellar environment. Stars like the sun are considerably less generous, and the miserly red dwarfs are worst of all. A one-tenth-solar-mass star like Proxima



Centauri will return little or nothing when its 6-trillion-year main sequence phase finally ends.

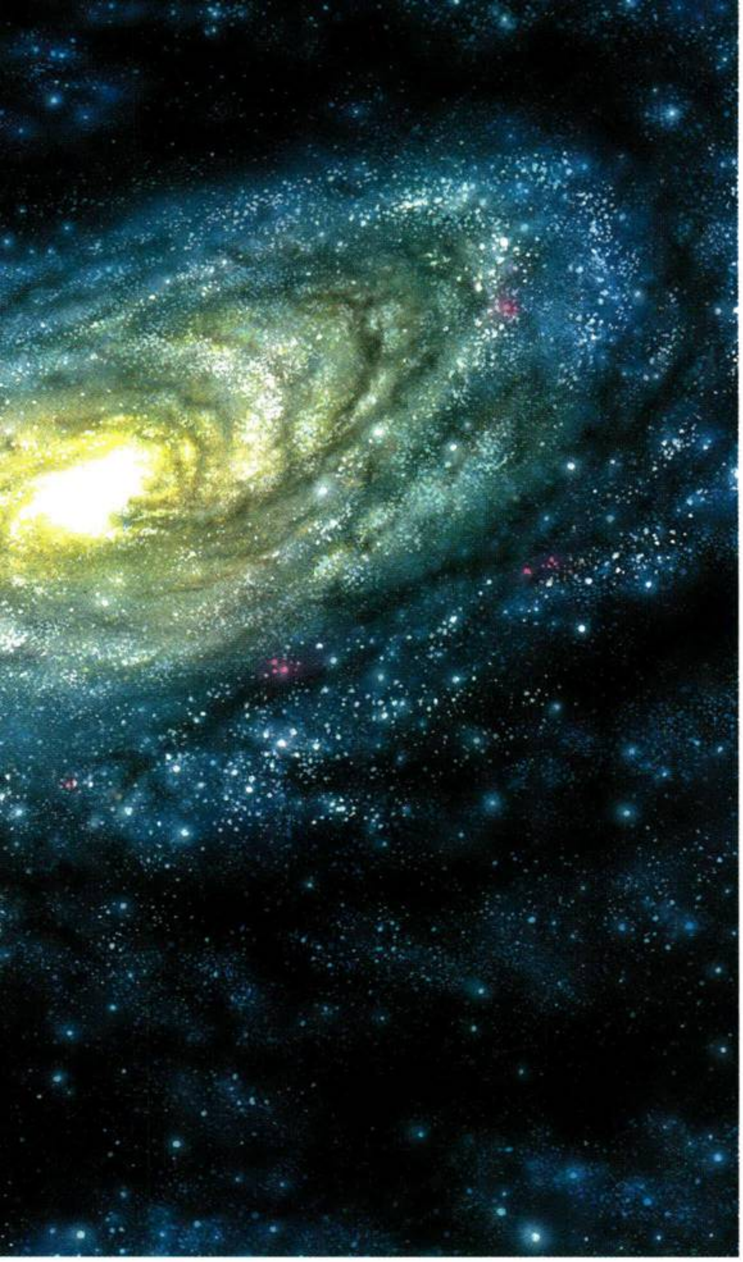
In addition to recycled mass from stars, nearly pristine gas rains down on the galaxy in packages called high velocity clouds. This new gas will form new stars over the next hundred galactic years. As the first Millennium winds on, the gas supply that is available to form new stellar generations will steadily decline. At the turn of the Galactic Millennium, one reliable source of new stars will be collisions between brown dwarfs. Every hundred billion years, two brown dwarfs will collide, merge, and jointly scrounge together enough mass to forge a bonafide (albeit small) red dwarf star.

As the Millennium wears on, the galactic inventory of glowing star-forming regions will slowly fade to black. On the brighter side, the final stellar generations should be richly endowed with planets. Radial velocity searches for planets around nearby stars have shown that stars that are highly enriched with heavy elements (51 Pegasi, for example) have a ten-times-better chance of harboring massive, short-period planets than the average sunlike star in the solar neighborhood. As stellar recycling continues, the material that forms new stars is increasingly rich in heavy elements, and we expect that planets will form easily around future generations of stars. Models of galactic chemical evolution suggest that the last generation of stars to be squeezed from the galaxy will be born with a composition that is roughly 20% hydrogen, 60% helium, and 20% heavier elements. These last stars will suffer from shorter lifetimes due to their low hydrogen content, but they will almost certainly be accompanied by a diverse and extensive retinue of planets.

## The Great Collision

On dark autumn evenings, the Andromeda Galaxy (M31) is faintly visible to the unaided eye as a small misty patch of light. Time exposures through telescopes reveal M31 as a glorious spiral galaxy, comparable in scope to the Milky Way. The Andromeda Galaxy is the nearest large galaxy to ours, and in sharp contrast to almost all other galaxies, it exhibits an overall blueshift; the galaxy is coming toward us at 75 miles per second.

The Milky Way and Andromeda galaxies constitute the core members of the Local Group of galaxies, our little cloud of some 35 galaxies that are gravitationally linked. Just as stars often double up, so too do galaxies, and the Milky Way



**As the sun becomes a red giant, the galaxy as a whole will see its own transformation. Some 6 billion years from now the Milky Way and Andromeda galaxies will come together and merge, eventually forming a giant, football-shaped galactic mass.**

and Andromeda constitute a binary pair. The Andromeda Galaxy is currently 2.5 million light-years away. Its velocity of approach indicates that it will experience a close encounter, and perhaps even a direct collision, with the Milky Way in about 6 billion years (60 galactic years from now).

Because of its great distance, the Andromeda Galaxy exhibits only tiny shifts in position from year to year as we see it on the sky. Astronomers cannot accurately measure how fast it is moving in the tangential direction. It might be headed almost directly toward us, or it might be tracing a relatively wide orbit. If the Andromeda Galaxy has a significant sideways component to its velocity, the "great collision" will not occur on the next close passage and we will continue to warily orbit M31. During the next close encounter, however, long, distorted tails of stars and gas will be drawn out of both galaxies. The mutual gravity of these tidal distortions will sap orbital energy from the galaxies and pump it into disordered motions of the individual stars. This process, known as dynamical friction, will force the orbits of M31 and the Milky Way to decay, and hence successive close galactic encounters will occur at progressively shorter intervals. At some time before the turn of the Galactic Millennium, a great collision is destined to occur.

The impending merger with the Andromeda Galaxy will be *the* defining event of the first Galactic Millennium. But this collision will be an odd sort of catastrophe. Because the volume of the galaxy that is occupied by stars is so small, even a single direct star-star impact is unlikely to occur as the galaxies rush together. From Earth's sweltering vantage in orbit around the red and swollen sun, more stars will be visible in the night sky, but little else will indicate that the Milky Way is being shredded. As the collision proceeds, the sun, and indeed all of the stars in both galaxies, will find their orbits scrambled and randomized. As the Andromeda Galaxy and the Milky Way lose their separate identities, the delicate rosette-like motions executed by stars orbiting in the flat galactic disks will be rudely converted to a chaotic jumble.

Although individual stars experience only a sharp jolt to their motions during a galactic merger, the Milky Way's population of giant molecular clouds will undergo severe collisions. These clouds are vast agglomerations of molecular hydrogen gas and dust — they contain thousands of solar masses and span thousands of cubic light-years. When these leviathans collide, severe compression and intensely vigorous star formation will result. Much of the Milky Way's already low reserve of star-forming gas will be expended in a dramatic, single burst. The massive stars that form will rapidly die in a firecracker-like string of supernovae, while the smaller stars mingle with the overall population of the composite galaxy. This forthcoming "baby boom" generation will represent the last significant cohort of young stars in our galaxy.

The merger of the Andromeda Galaxy and the Milky Way should leave behind a football-shaped elliptical galaxy, a generic outcome of galactic collisions. Within this composite, the orbit of our white dwarf sun will be highly chaotic. The sun and its planets will tumble erratically through the elliptical gravitational well. Over time, the solar system's trajectory will resemble the path of a bee flying about randomly within a closed room. The concept of a galactic year will have assumed a strictly historical connotation.

## A View From the Future

Let's imagine how the scene on Earth might appear on the eve of the Galactic Millennium. The white dwarf sun is several thousand miles across and subtends only a pinpoint in Earth's sky. The sun has long since crystallized and its surface has cooled to a frigid 63° K, roughly the temperature of liquid nitrogen. This steady temperature is maintained with energy supplied by dark matter particles annihilating in the degenerate interior. The sun, now devoid of visible light, glows faintly in the infrared.

On the hard basalt surface of Earth, the temperature is about 1° above absolute zero. Faint remnants of geothermal heat give some areas a bit of sterile, lingering warmth. The atmosphere is gone. Every trace of the once-flourishing biosphere has vanished. Here and there, the surface has been cratered by increasingly infrequent asteroid and comet impacts.

The gas giant planets are similarly dulled by age. Jupiter has finished contracting, but its core remains very hot. Its surface temperature hovers near 10° above absolute zero. The fury of vortical hurricanes — such as the Great Red Spot — has largely subsided, and molecules such as ammonia, water, and methane have rained down to much lower, warmer levels in the atmosphere. The gas at Jupiter's surface is nearly pure hydrogen. In the dim illumination provided by starlight, Jupiter and its gas giant brethren loom as featureless, blue-green spheres.

Beyond the solar system, the sky contains a surprising number of bright red stars, which merge into an impressive glow in the direction of the gas-free and unobscured center of the galaxy. Although massive, young, blue stars are exceedingly scarce, the total amount of starlight is larger than at present. In the overall history of the universe, most stars are less massive, much dimmer, and far longer-lived than the sun.

At the Galactic Millennium, the one-half solar mass stars that are now commonplace and inconspicuous K dwarfs (such as Groombridge 1618b, or Lacaille 8760) have increased their brightness by a factor of a thousand as they ascend the red giant branch. Given the run-down condition of the solar system on the eve of the Galactic Millennium, it's reassuring to know that the sky will remain ablaze with starlight, twinkling with the light of countless powerful stars that have not yet burned themselves out.

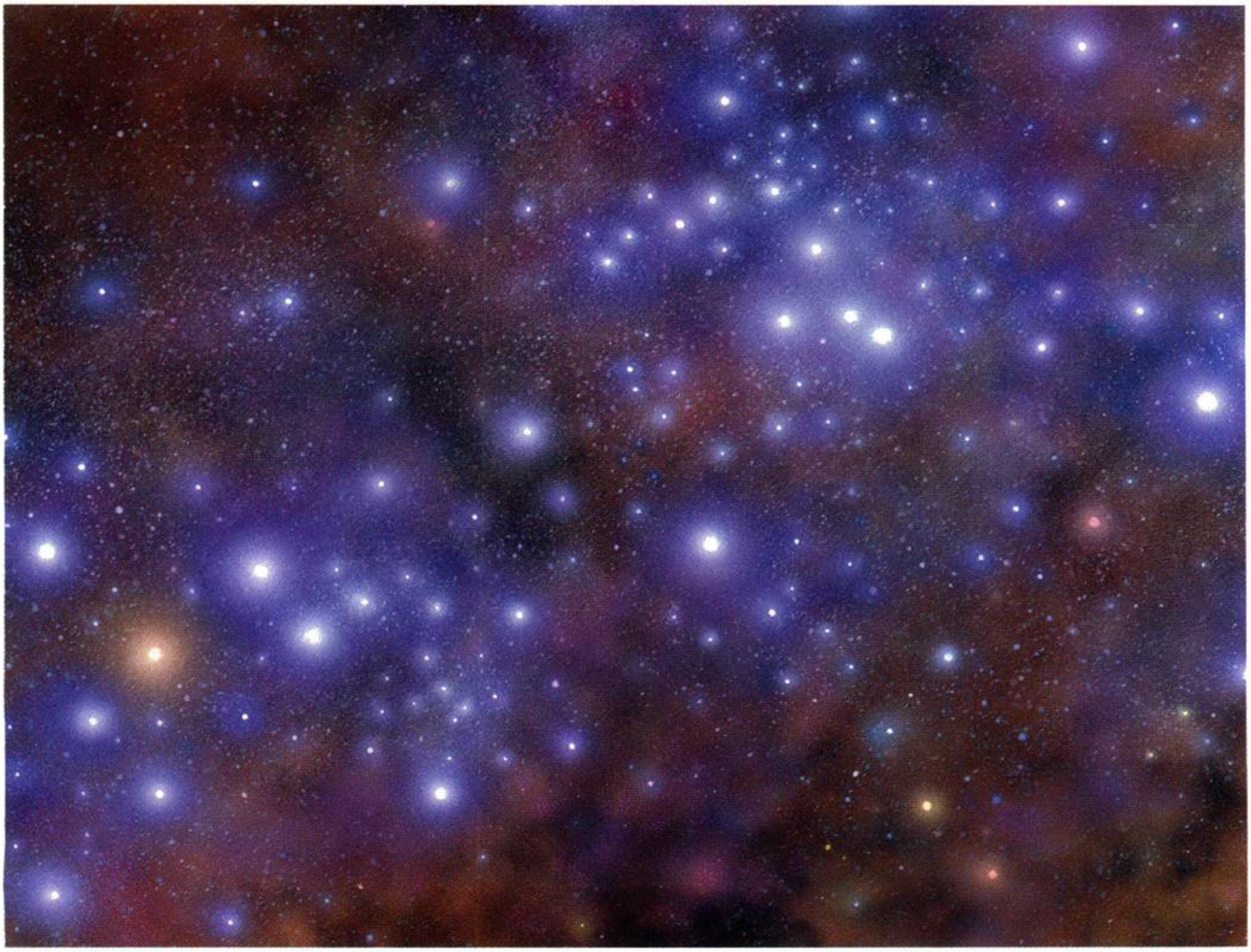
## Accelerating Expansion

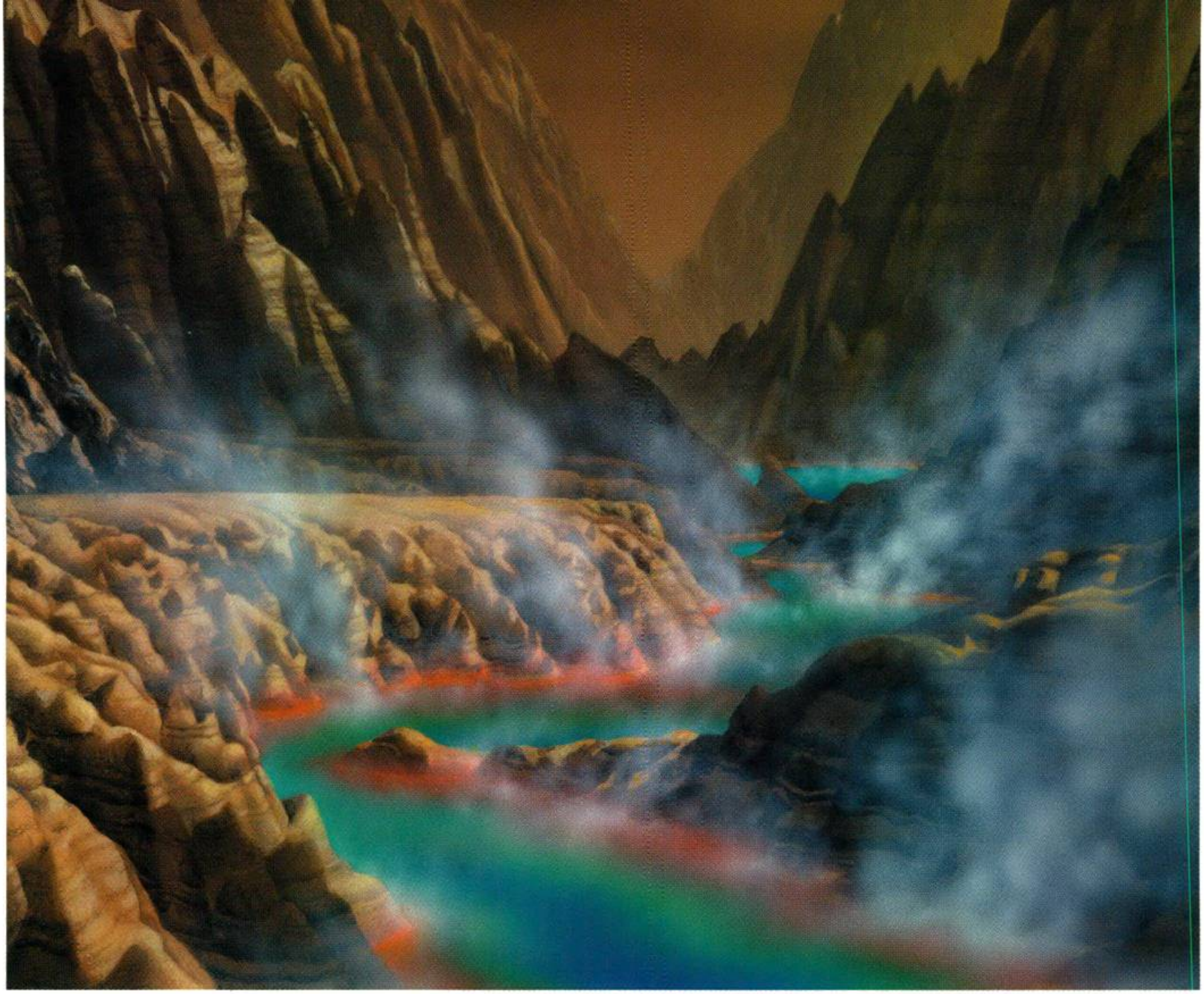
In the 1920s, Edwin Hubble showed that galaxies are flying apart and that the universe as a whole is expanding. Over the past several years, astronomers have deduced that the rate at which galaxies are receding from each other is accelerating. Even more surprisingly, this acceleration is apparently caused by a mysterious form of dark energy associated with the vacuum of empty space.

At first, the possibility of accelerating expansion conjures up an image of a thrill ride into the future. The reality, however, is much more constraining. By an amazing coincidence, we seem to be living in an epoch where the energy density in matter (including both ordinary baryonic matter and exotic dark matter) is comparable to the dark energy density of empty space. More specifically, at the present time, the cosmic energy budget appears to be split roughly 70/30 between the vacuum energy density and the matter energy density. The acceleration of the cosmic expansion is now evident through careful measurements of the brightnesses of distant supernovae. But we have not yet begun to see the full effects of accelerating expansion.

At the turn of the Galactic Millennium, it will not take a discerning observing technique to register the global impact

**As a result of the galactic merger, a renaissance of starbirth will occur as gas compresses into a tumultuous wave of firecracker-like new suns, the last hurrah of the galaxy until it ages toward a "big dark."**





of the vacuum energy density — most of the galaxies will become invisible. The galaxies that we see today are those whose light has had time to reach us. As the cosmos ages, light has a longer time to travel and more of the universe tends to be connected together. But this trend is directly opposed by the cosmic expansion, which moves galaxies farther apart. If the expansion is slow, then light travels fast enough to connect more of the universe as it ages, and thus more galaxies would come into view. But if the universe is accelerating, the rapid expansion wins this battle, and galaxies fly apart from each other faster than their light signals can connect them together. When the accelerated expansion of our universe really kicks in, the intervening space between the Milky Way and distant galaxies will be created so rapidly that they will exponentially redshift and disappear beyond the horizon.

At the close of the Galactic Millennium, the population of galaxies visible in Earth's skies will be considerably smaller than those that we see today. This impoverishment in the number of galaxies visible at the Galactic Millennium will presage the universal "Y20K" problem. After several galactic millennia, all external galaxies not bound to our Local Group will have irrevocably disappeared from view. A half trillion red dwarfs, brown dwarfs, and stellar remnants, a trillion or so planets, a cloud of dark matter, and a giant central black hole will constitute the entirety of the visible universe.

**Long before the transformation of the galaxy, within the next billion years, Earth will face a "moist greenhouse" that will drive temperatures upward, killing its life and changing it into another Venus.**

## Caveat

The preceding story is not the final word on the Galactic Millennium. Instead, it represents the current view of the future pieced together from our present understanding of physics and astronomy. If this story had been written fifty years ago, almost nothing described above would have been included in this raft of predictions. Indeed, the acceleration of the cosmic expansion has only been given serious credence for several years. It is quite possible that a better understanding of the true nature of the dark energy density might lead to a brighter prediction for the ultimate future.

It has recently been shown that it is possible — in principle — to use Jupiter, Saturn, and an asteroid to gradually push Earth away from a steadily brightening sun. Although such astronomical engineering projects remain purely theoretical at present, who knows what other directed processes might alter the course of our distant future . . . ■

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*Greg Laughlin is an astronomer at NASA's Ames Research Center in Moffett Field, California. Fred Adams is an astronomer at the University of Michigan. Together, they wrote* The Five Ages of the Universe: Inside the Physics of Eternity *(Free Press, 1999).*

# NOTHING GETS

> *String theory is a piece of twenty-first-century physics that fell by chance into the twentieth century.*
>
> **– Edward Witten, Institute for Advanced Study, Princeton**

# STRUNG OUT

**From the book *The Hole in the Universe: How Scientists Peered over the Edge of Emptiness and Found Everything.***

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We've come a long way from the bleak emptiness of antiquity. Modern physics animated the void and gave it structure. Today we know the vacuum fluctuates, creating particles and forces. The background of spacetime warps, producing gravitational pull.

Still, it is a relatively simple picture: large-scale spacetime rolls along smoothly while small-scale vibrations of the fields set nothing all atwitter.

Is that all there is to nothing? Is it enough?

The most cursory glimpse at the world we perceive through our senses is far richer than this nothingness can seem to support. Things sprout, drip, spew, dive, wander, branch, breathe, trickle, fizz, pierce, curl, spiral, branch, shine, flicker, and fade. The shapes and motions are rich and irregular. The nothing we have met so far seems far too neat to give rise to all of messy reality.

In truth, of course, it's not all that hard to get complexity from simplicity; it happens all the time. From simple electrons, protons, and neutrons, everything in nature grows — argon and krypton, gorillas and begonias, skyscrapers and stars. Intricate crystals spring from simple seeds, gurgling babies, from single cells; consciousness emerges from nets of virtually identical neurons.

And yet, there would be a more satisfying symmetry to the relationship between something and nothing if the ultimate backdrop for everything were more than sinusoidal vibrations of fields and gently rolling four-dimensional landscapes.

As it turns out, nature has been dropping hints over the past few decades that nothing may indeed be far richer than even Einstein and the quantum mechanics thought. This new geometry of emptiness curls, folds, loops — even rips and tears — in eleven (or perhaps twelve) dimensions of space and time.

The more complex landscape comes with a set of ideas generally known as "string theory" — short for superstring theory — and more recently M-theory, which can stand for magic, mother, mystery, matrix, or membrane theory, almost according to taste. As described by M-theory, the entire universe arises from the harmonics of vibrating strings, membranes, and blobs in eleven dimensions.

These unseen dimensions curl around one another in strange, convoluted shapes, forming holes, knots, and handles, leaving pieces of the universe oddly isolated, perhaps stranded on islands or hanging on to the rest of the cosmos by tenuous threads.

Our entire tangible universe may be trapped on a nine-dimensional membrane attached to a larger, ten-dimensional universe only by gravity.

String theory strikes some as strangely beautiful, others as nothing short of bizarre. Ignored by all but a few smitten followers until a few years ago, it has suddenly become part of the common parlance — tossed around at physics meetings with as much familiarity (and sometimes disdain) as "Monica" and "Bill." Recently, its success at solving certain long-standing puzzles has won over even some of its most vocal critics.

Physicists first became attracted to string theory because it, and it alone, resolves the glaring mismatch between the laws that rule the large-scale cosmos (Einstein's theory of gravity) and those that run the microcosmos (quantum mechanics). In string theory, not only do the two sets of rules get along together, they need each other; they require each other to exist. On close inspection, even the unruly quantum spacetime "foam" becomes the raucous song of vibrating strings.

The trick to making this difficult marriage work seems deceptively simple: The main reason that quantum mechanics and gravity don't mesh is that the two together produce infinite solutions to equations. Everywhere gravity meets the quantum, infinity pops up, and infinite solutions are nonsense. They are the dead canaries that tell physicists the laws of nature are breaking down.

But the infinities appear in part because present-day theoretical physics allows particles to be infinitely small, and space and time to squeeze down to infinitely small specks. Properties of space, time, and particles approach the dreaded zero with impunity. And zero always opens the door to infinity.

String theory solves that most fundamental of problems by doing away with infinitely small particles. It doesn't allow infinitely small anything; the loop of string is the smallest allowable size. Like glasses that blur the view, strings erase the problem. The incompatible partners, gravity and quantum theory, fit snuggly together out of sight, under the covers of size. Indeed, because the strings prevent anything from getting infinitely small, they smear out many previously troubling properties of space and time at infinitely small scales. "You never get to the point where the disasters happen," explains physicist Nathan Seiberg of the Institute for Advanced Study. "String theory prevents it."

And if string theory is right, it would do a great deal more than mend the rift between gravity and the quantum: It could explain almost every outstanding question in fundamental physics — from how the quarks are trapped inside the vacuum to why the vacuum is the way it is in the first place. Because string theory brings together all the laws compatibly under one happy roof, it could well reveal that every tick of a clock, every barking dog, every dying star, flows from a single master principle, a single grand equation.

Fittingly, the power from string theory arises at least in part from the fact that it embodies a more perfect symmetry than general relativity or quantum theory alone; from its higher-dimensional perspective, string theory naturally embraces a multitude of seemingly disparate realities.

## NOTHING TO SEE

*Why extra dimensions instead of little green people? If they were small enough, we couldn't see them either. — Brian Greene*

What is string theory exactly? It says simply that the building blocks of nature are no longer particles, but vibrating strings of some fundamental, unknown “stuff.” Depending on the exact geometry of the vibrating string, it will produce different harmonic chords, just as a piano produces a different sound than a flute.

In turn, the way the string vibrates determines a particle’s mass, its electric charge, its spin, and any other properties. By changing its mode of vibration, the string, in Andrew Strominger’s words, “can masquerade as an electron or a photon or a graviton or any other particle of nature.” In a sense, the resonant patterns are equivalent to the particles, the universe the symphony they sing.

While some strings have free ends, others curl into loops. They interact with one another by joining and splitting off again, branching into new strings and loops, growing and shrinking. If a universe built up from pointlike particles resembles a city made of LEGO blocks, the universe of strings looks a lot more like a tree.

How do we know they’re there if we can’t see them?

We don’t see the strings, in part, because they are unimaginably small. Consider that it takes about a million atoms to cross the period at the end of this sentence, and that it takes about 100,000 protons to equal the size of an atom. Then think how many protons it would take to cross New Jersey. That’s how many strings could, theoretically, fit inside a single proton. For the more quantitatively minded, the string scale is $10^{-33}$ centimeters (a fraction with 1 in the numerator and the number 1 followed by 33 zeros in the denominator).

But size is only one reason we can’t see the strings. They also curl around dimensions unfamiliar to our senses. Consider an ant living on a beach ball. To the ant, the beach ball seems a flat infinite space — like the Earth did to our forebears. Or think of a garden hose: seen at a great distance, it looks like a one-dimensional line. In fact, it curls around a second (from our perspective unseen) dimension.

If string theory is right, we are all ants living on garden hoses that curl and twist into at least six unseen dimensions. Sometimes, dimensions wind around one another, creating extra-energetic (that is, massive) particles. Sometimes, the dimensions flatten out, or deflate, like a three-dimensional beach ball flattened by a truck. These transformations can produce astonishing effects, such as turning something that looks like an elementary particle into something that looks more like a black hole. And vice versa.

The exact shapes of these extra dimensions are critical. Just as the exact shape of a trumpet or violin determines the sounds it can make, so the topology of the extra dimensions determines the possible particles produced by the strings. The topology of the extra dimensions in which the strings vibrate, in other words, determines the ingredients available to make our universe.

Every time you sweep your hand through space, it also sweeps through all the extra curled-up dimensions. But they are so small, and your hand circles through them so fast, that it gets back to its starting point before anyone can notice.

How do we know they’re there if we can’t see them? Why do so many physicists put so much faith in something so far removed from the palpable, testable, world? The reason is, the theory seems to work. Physicists have trust in string theory for the same reason most people have trust in computers or jet planes and other things they don’t understand — these things work for us; they take us where we want to go; and all things considered, they seem to be fairly reliable.

No one knows, as yet, exactly what string theory will turn out to be; but because it has performed so many amazing feats, many physicists are willing to wait to see where it takes them. And at least until experiments prove them wrong, they are willing to trust that something more real than little green people lies hidden in the ultra-small world of extra dimensions. “Nobody in this field is clever enough to have invented something like this,” said Strominger. “It’s clearly something that we discovered.”

## SOMETHING WONDERFUL

*Nothing is too wonderful to be true. — Michael Faraday*

So why is it that nature is almost perfectly symmetrical — but not quite? Why do so many physical quantities approach zero so closely, only to never quite arrive? Why did matter nudge ever so slightly ahead of antimatter in the chaos of mutual annihilation that reigned in the early years of the universe? Why are neutrinos so tiny? Why does time run one way?

What, in other words, is the reason for the pervasive imperfection that makes everything possible?

Richard Feynman raises this question in his Lectures on Physics. “No one has any idea why,” he says.

He suggests, however, that the answer might have something to do with the fact that perfect symmetry is simply too beautiful to be true. He then tells the story of a gate in Neiko, Japan, known as the most beautiful gate in the country. The gate is elaborately carved with designs that are perfectly symmetrical except for one small element that is carved upside down. It was carved upside down deliberately, so the story goes, in order to mar the perfection — so that the gods would not become jealous and angry.

“We might like to turn the idea around,” Feynman concludes, “and think the true explanation of the near symmetry of nature is this: that God made the laws only nearly symmetrical so that we should not be jealous of His perfection.”

Luckily for all of us, nothing may be too beautiful to be true, but everything else is not. **A**

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*Los Angeles Times science columnist K. C. Cole teaches at UCLA and serves on Astronomy’s Editorial Advisory Board.*

# *Magic* AT TWO MICRONS

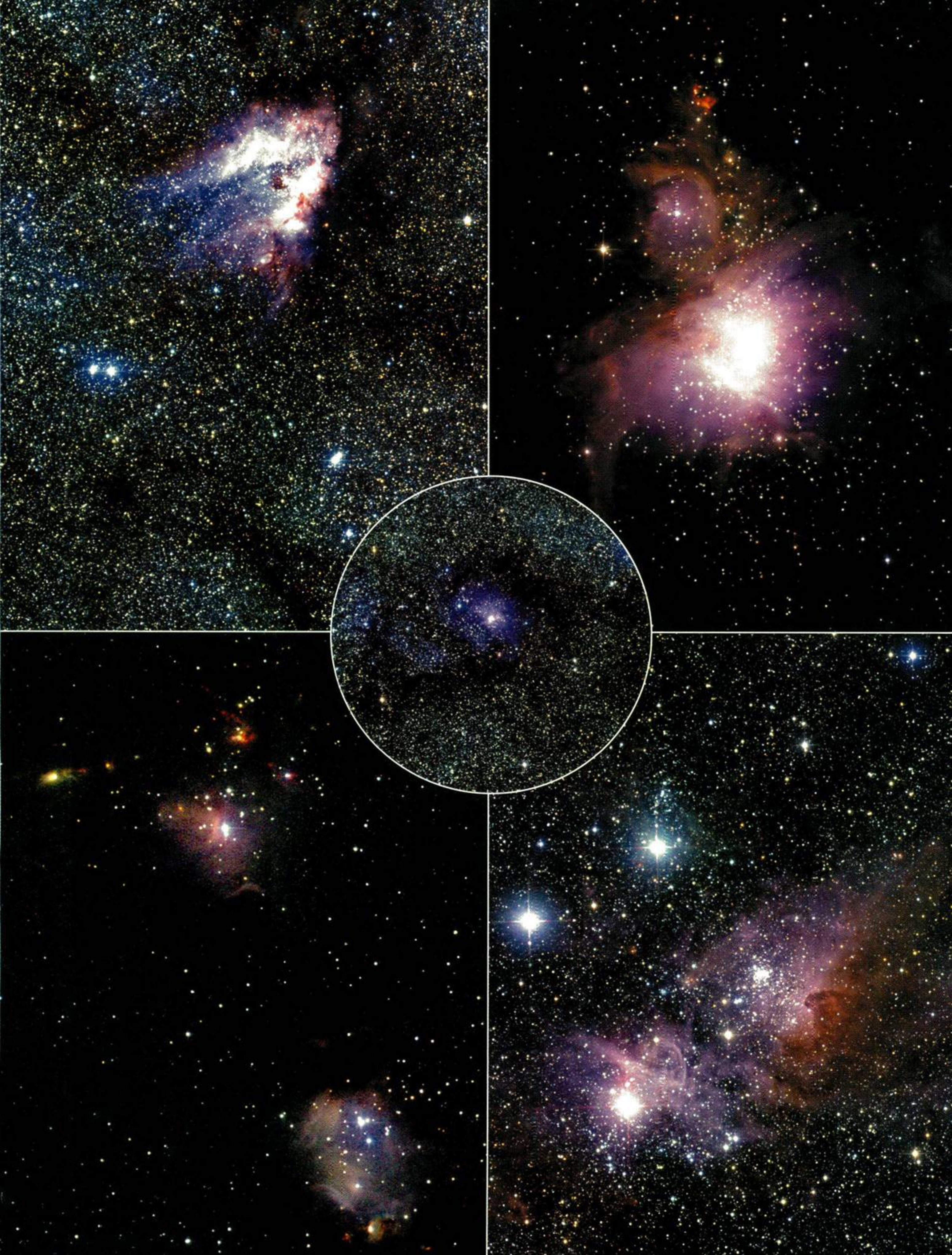
*This near-infrared all-sky survey brings you the entire cosmos.*

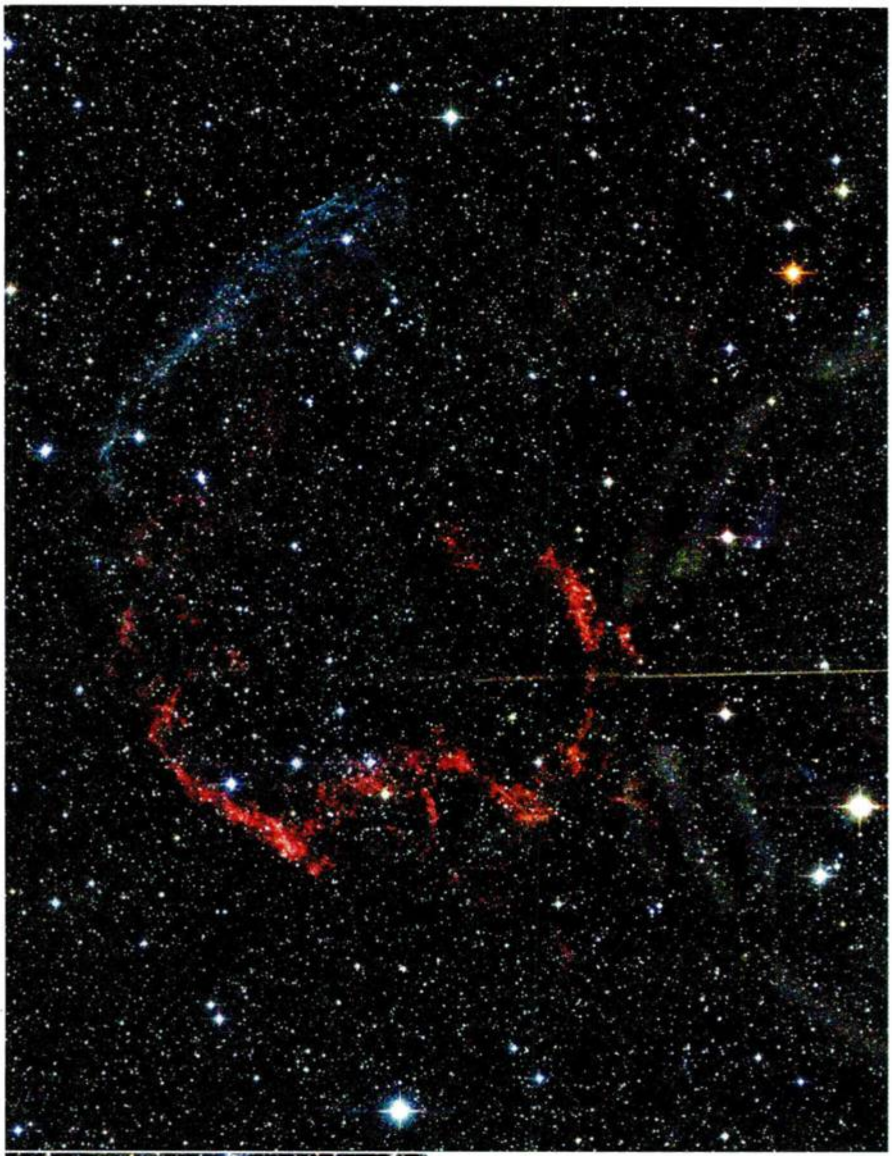
**by William Schomaker**

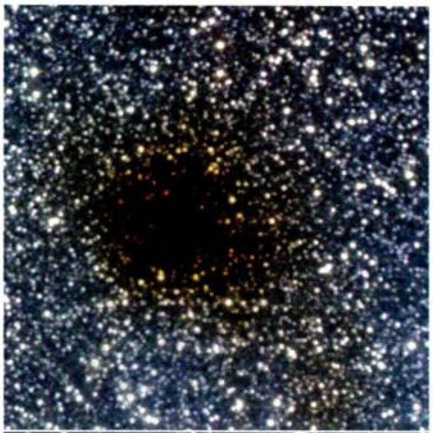
With a healthy injection of ingenuity and imagination, ordinary ingredients often yield extraordinary results. A standard deck of playing cards or a half-dollar coin can transcend reality in the hands of an accomplished magician. Pigment and canvas come to life under the creative spell of a painter. And with little more than aluminized glass and digital strings of 1s and 0s, astronomers routinely bring the cosmos down to Earth.

Earlier this year, astronomers with the Two-Micron All-Sky Survey (2MASS) continued the long tradition of making magic from the mundane as they placed the final stamp on an effort to map the entire

**In a different light: Deep-sky standards (clockwise from top left), such as the Omega Nebula (M17), the Orion Nebula (M42), the Eta Carinae Nebula (NGC 3372), M78 in Orion, and the Lagoon Nebula (M8) at center, appear eerily unfamiliar in near-infrared light.** All photos: 2MASS/UMASS/Caltech/IPAC







**Clockwise from top right: On the cusp of star-forming collapse, dark cloud FeSt 1-457 hides 20 magnitudes of starlight behind its dense bulk. RCW 87 lies just one degree from the galactic plane. Supernova remnants IC 443 (top) and RCW 103 (bottom) glow in the brilliant red and blue-green hues of molecular hydrogen and ionized iron emission, respectively.**

sky at near-infrared wavelengths (see "Near-Infrared," page 55). The ambitious collaboration, which joined astronomers, engineers, and computer scientists from the University of Massachusetts – Amherst (UMASS), Caltech's Infrared Processing and Analysis Center (IPAC), and the Jet Propulsion Laboratory (JPL) in Pasadena, California, completed its target mission on February 15, 2001.

But the real beauty of 2MASS can be found in its simplicity. At the dawn of the 21st century, with ground-based telescope apertures ballooning to ten meters or more, the twin 1.3-meter 2MASS light buckets are rather run-of-the-mill pieces of equipment. What's more, 2MASS detectors are nothing more than stock, 1980s-technology, 256 by 256 pixel CCD arrays. How is it, then, that these simple ingredients yield such cutting-edge results?

UMASS astronomer and 2MASS Principal Investigator Michael Skrutskie owes the success of 2MASS to using easily obtainable equipment (insurance against the inevitable hardware breakdown) and to the development of efficient observing and data processing procedures. Indeed, the process efficiency and magnitude of data collected by 2MASS in just over three years is unprecedented.

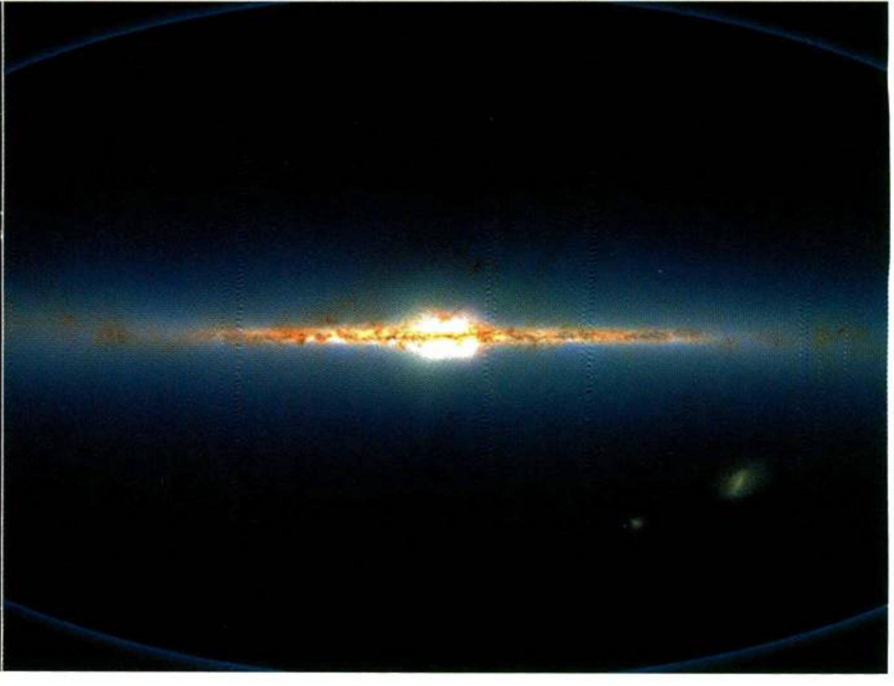
The 2MASS scopes, one located at Whipple Observatory atop Mount Hopkins in Arizona and the other at Cerro Tololo Inter-American Observatory in Chile, aimed skyward on nearly every clear night since June 1997 (for 2MASS–North) and March 1998 (for 2MASS–South). And all the while, the 2MASS team hasn't skipped a beat. They even designed custom data analysis software on the fly, as 24 terabytes of raw data — enough to fill several thousand home computer hard drives — came rolling in.

2MASS is the first high-resolution digital survey of the entire sky. As such, it holds a special place in the future of astronomy. With object catalogs already listing more than 300 million stars and galaxies, 2MASS has mapped countless unknown objects while casting new light on familiar favorites. In addition, 2MASS astronomers have uncovered whole new classes of cool stars (L dwarfs and T dwarfs), observed galaxies behind the disk of the Milky Way, and discovered a host of dust-shrouded active galaxies and quasars unseen by earlier infrared surveys.

Soon-to-be-launched observatories, like NASA's Space Infrared Telescope Facility (SIRTF) and Next Generation Space Telescope (NGST), will employ the vast 2MASS data set as a roadmap for divining even more discoveries. In addition, infrared astronomers using the next generation of 8-meter class telescopes, like Gemini and the VLT, now have a whole new set of objects to investigate courtesy of 2MASS.

UMASS astronomers handled observatory design and data gathering, while IPAC staff members developed the data processing and storage algorithms. Because most of the data processing software was written on the

**Peering toward the Milky Way Galaxy's center (bottom right), 2MASS puts the whole sky into perspective. Beyond the Milky Way's veil, NGC 891 (below) and massive galaxy cluster Abell 3627 (top right) — home of the infamous Great Attractor — pose for 2MASS.**



fly, crews at IPAC have recently embarked on a two-year project to process all of the 2MASS data a second time, to make sure that the data set is completely uniform. When all of the data analysis is done, four million high-resolution Atlas images will have been released to the scientific community and to the public — two million of which have already been released and used for everything from discovering new stars, galaxies, and quasars to decorating computer desktops.

You can browse the entire collection of 2MASS images at http://www.ipac.caltech.edu/2mass/gallery/second/ or http://www.ipac.caltech.edu/2mass/index.html. **A**

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*William Schomaker is an associate editor for* Astronomy.

## NEAR-INFRARED

All 2MASS data were simultaneously gathered in three near-infrared bands: 1.25 microns, 1.65 microns, and 2.17 microns. (One micron = one millionth of one meter.) It just so happens that the near-infrared is a perfect spectral region to probe the Milky Way Galaxy for understanding of its structure and constituents. For example, red giant stars output the lion's share of their energy as near-infrared photons, making one to three microns an ideal wavelength range to trace the stellar mass of the galaxy.

Infrared surveys benefit from the fact that long-wavelength, near-infrared light is less susceptible to scattering by dust in the Milky Way than short-wavelength visible light. Visible light is heavily scattered by dust in the Milky Way because the dust particles are roughly the same size as the wavelength of visible light, whereas near-infrared light passes freely through the smaller bits of dust. This allows 2MASS to see the Milky Way for the first time in high-resolution detail from the inside. The results are simply astonishing.

## RECIPE FOR SUCCESS

**Roc Cutri:**
**2MASS Project Scientist**

"The facilities collected data 99.5 percent of the available time during the mission, and only a few nights were lost due to hardware failures. That's a remarkable record for any astronomical observatory, on the ground or in space."

"The total data volume was difficult, with roughly 24 terabytes of raw image data collected at the observatories. So we had to keep up with a fire hose of incoming data. There aren't a lot of existing software systems that were built to handle things like that."

**Michael Skrutskie:**
**2MASS Principal Investigator**

"It was really a challenge to cobble together the funding from various agencies for this project. The sky at these wavelengths had never been surveyed to this depth before and it really needed doing, but I don't know that any one funding agency wanted to step up to the plate and be responsible for generating that survey."

**Rae Stiening:**
**2MASS Project Manager**

"We were very careful at the beginning to make a clear set of specifications for what we were going to do. And then every decision could be based on that standard, something that's essential in a project where there's not a lot of money around."

**Jack Dembicky:**
**2MASS — North Telescope Operator**

"When an instrument looked like it was going to have a problem, we had spare parts already there in case we needed to fix it. It was a proactive, rather than reactive, process."

**John Huchra:**
**2MASS Project Scientist**

"What we're doing is producing the best map of the local universe that you're going to see — for a long stretch of time to come."

**Martin Weinberg:**
**2MASS Project Scientist**

"Very few surveys that have claimed to be 'all-sky' really have been 'all-sky,' but 2MASS is really 'all-sky.' "

**Opposite: Infant stars, still wrapped in their dusty shrouds after two million years, litter the star-forming region RCW 38.**
**Clockwise from top right: The Trifid Nebula's namesake dust lanes stand out in the near-infrared. Emission nebulae NGC 3603 (left) and NGC 3576 are among the largest in the galaxy. Embedded star clusters light up RCW 108.**

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#497 Autostar
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ETX-125EC

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We've been helping people choose the right telescope since 1979. We have the experience to help *you* pick the scope that fits your needs . . . *and your budget* . . . from the many Meade, Celestron, TeleVue, Takahashi, and Questar telescopes we stock at discount prices from $99 to $27,995.

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On average, we keep over 1000 telescopes in stock. At an average weight of 50 lbs. each, that means we usually have well over 25 tons of telescopes in inventory at any given time. We don't know of many dealers – if any – who stock telescopes in those quantities . . . *no matter what they claim.* But we do. And we don't just stock telescopes in large quantities. We have literally tons of accessories, as well. Eyepieces, filters, CCD cameras and autoguiders, dew caps, Barlows, off-axis guiders, illuminated reticle eyepieces, electric focusers, T-adapters, tele-extenders, counterweights, and much more.

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Meade ETX-90RA,
*with #883 tripod,*
***now only $349!***

Thanks to a special purchase, you can get this **Meade ETX-90RA,** including a normally optional tripod, for $295 less than the regular $644.95 package price! This is the original non-computerized ETX-90RA. It has a battery-operated right ascension motor drive, 9mm *and* 25mm 1.25" modified achromatic eyepieces, finderscope, tabletop tripod – plus the normally optional (for $199.95) #883 full length tripod. If you want an excellent second scope, or a super starter scope at a big savings, this is it! Less than 200 available at this low price.

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4.5" Voyager
**$149^95^**

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Meade ETX-90EC
***now only $495!***
(Autostar optional)

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## A $50 rebate on a Celestron 4" go-to Mak cuts the price to $549!

The 4000-object computer of the new **Celestron NexStar 4** go-to Maksutov-Cassegrain is standard equipment, not an option as it is with some scopes. The computer hand control can be used even when docked conveniently in the scope's sleek single fork arm mount. A long eye relief Star Pointer red dot finder makes aligning on the skies a snap. The battery-operated tabletop NexStar is so easy to use that you'll be observing only minutes after you take it out of the box. And the limited time $50 rebate makes it easier than ever to get into astronomy.

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NexStar 114HC scope with computer hand control

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after $15 mail-in rebate

We bought over 650 of these computerized go-to Celestron NexStar scopes at great prices, and have been passing our savings on to you. Now, Celestron's factory-direct rebates make them an even better buy! You get two 1.25" eyepieces, a red dot finder, dual DC motor drives with hand control, software to control the scope from a computer, an adjustable height metal tripod with accessory tray, *and* a separate go-to computer hand control. Both are so sensationally easy to use that you'll be observing in minutes.

A review in *Astronomy* said, "What fun to press "M31" on the hand control, then watch as the Andromeda Galaxy slides into the field of view! . . . a great telescope for someone as young as 12 or 13." The **NexStar 114**, left, is a 4.5" aperture f/9 reflector. The **NexStar 80**, right, is an 80mm f/5 refractor. Both make computerized astronomy amazingly affordable.

> Folks, I just wanted to say that I love your company, service, and quality products. Your volume purchases ensured that I got my new LX90 (sold out nearly everywhere) faster than anywhere else I checked. You've got a faithful customer!
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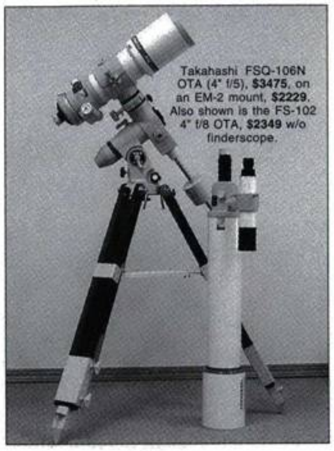
Takahashi FSQ-106N OTA (4" f/5), **$3475**, on an EM-2 mount, **$2229**. Also shown is the FS-102 4" f/8 OTA, **$2349** w/o finderscope.

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We also stock the 22" long Takahashi **FSQ-106N** 4" 4-element f/5 dual fluorite astrograph apo refractor OTA. It's another great travelling scope.

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A $100 mail-in rebate drops the price of this **Celestron NexStar 8** go-to SCT to its lowest price ever! You get an adjustable height tripod, Starbright multicoated optics, red dot finder, 40mm Plössl eyepiece, and a computer with 18,000+ objects in its memory. It's enough scope to keep you busy and happy observing for the rest of your life!

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## Fuji astro binoculars!

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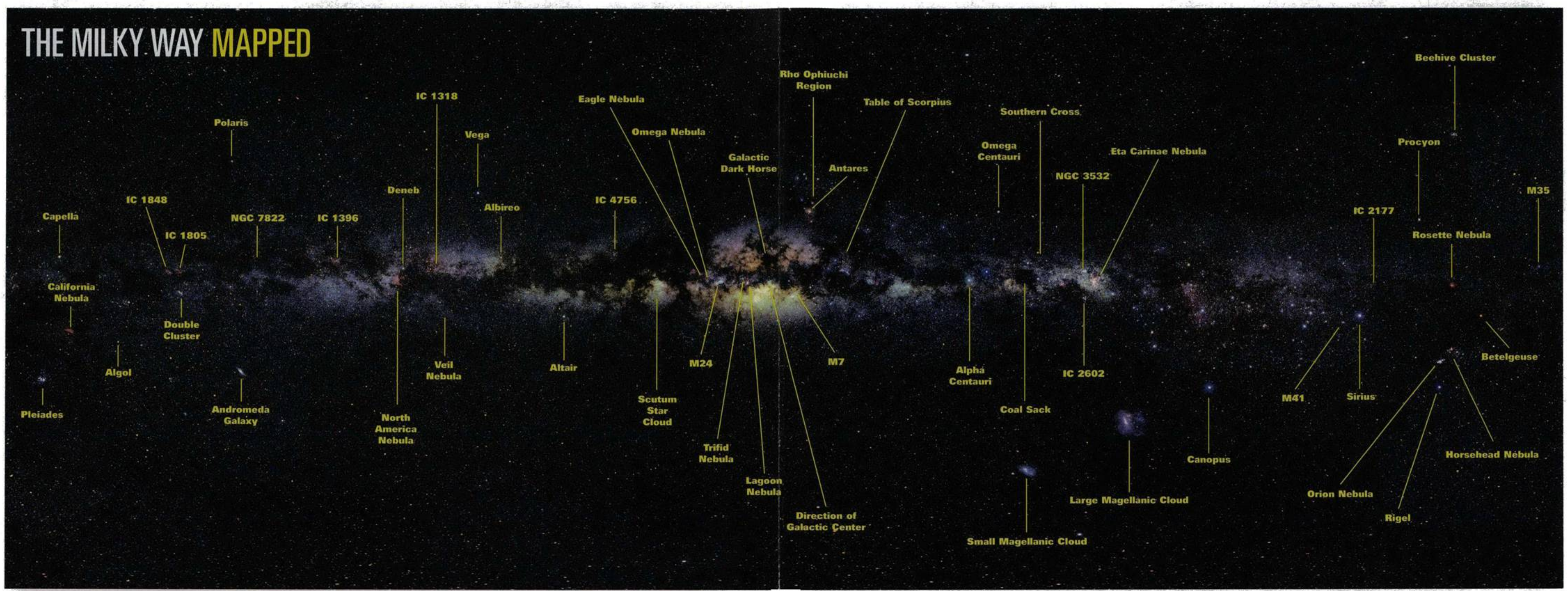
# THE MILKY WAY MAPPED


Capella
California Nebula
Pleiades
IC 1848
IC 1805
Double Cluster
Algol
Polaris
NGC 7822
Andromeda Galaxy
IC 1396
IC 1318
Deneb
North America Nebula
Vega
Albireo
Veil Nebula
Eagle Nebula
IC 4756
Altair
Omega Nebula
Scutum Star Cloud
M24
Galactic Dark Horse
Trifid Nebula
Lagoon Nebula
Rho Ophiuchi Region
Antares
Table of Scorpius
M7
Direction of Galactic Center
Southern Cross
Omega Centauri
Alpha Centauri
Coal Sack
Small Magellanic Cloud
NGC 3532
IC 2602
Eta Carinae Nebula
Large Magellanic Cloud
Canopus
IC 2177
M41
Sirius
Orion Nebula
Rigel
Beehive Cluster
Procyon
Rosette Nebula
M35
Betelgeuse
Horsehead Nebula

# A POLAR VIEW OF THE GALAXY

the sky visible with the naked eye, minus three, is a member of the Milky Way Galaxy. The Andromeda Galaxy floats just off the edge of the Milky Way's plane and will merge with the Milky Way some 6 billion years from now. Its fuzzy, oblong shape appears clearly in the lower left of the photograph. In the Southern Hemisphere sky, the Magellanic Clouds are bright naked-eye targets.

Out under the sky, armed with a pair of binoculars, distinctions among the stars materialize. Clusters and double stars pop into view. The vibrant stars that define the shapes of the constellations are no longer lonely beacons but just the brightest members of huge entourages. Cygnus the Swan's head, Albireo, becomes a stunning yellow and blue double star. If you refer to Cygnus as the Northern Cross, Albireo is the "bottom" star in the cross.

Acrux, Alpha (α) Crucis, could be considered Albireo's southern analog. The Southern Hemisphere's cross, Crux, contains this brilliant double star. However, it's more difficult to perceive, or "split," in binoculars. Unlike the sun, double or multiple systems are the norm: Approximately 60 percent of all stars exist in double or multiple systems.

Clusters of stars, such as the Hyades and Pleiades, are obvious to the naked eye. Others need just a little magnification. The Double Cluster in Perseus, NGC 869 and NGC 884, is an amazing sight when given a little boost through binoculars. These neighboring stellar nurseries then betray their many members. Those ancient denizens of the deep, globular clusters, float majestically away from the galaxy's disk, formed from matter coalesced as the disk itself came together. The brightest example to spot on Mellinger's panoramas is Omega Centauri in the Southern Hemisphere.

Nebulae, gas clouds coming together to form new stars or the cast-off remains of dying stars, are best observed through telescopes — and the larger the mirror or lens, the better. In the direction of the Milky Way's center floats the red and blue conglomerate of the Trifid Nebula (M20), and just to its south is the Lagoon Nebula (M8).

Standing apart from the majority of the Milky Way's denizens is the expansive California Nebula (NGC 1499). Its faint, 2.5° length appears strongest through photographs such as this one. Many other bright nebulae require patience and dark skies for optimum viewing. See the finder map above for many identified objects.

Carefully examine the myriad glows and streaks of stars and nebulae on this magnificent image, comparing it with your favorite star atlas. Then make a target list outside and, on the darkest, most transparent night you can find, soak in the beauty of our home galaxy. ■

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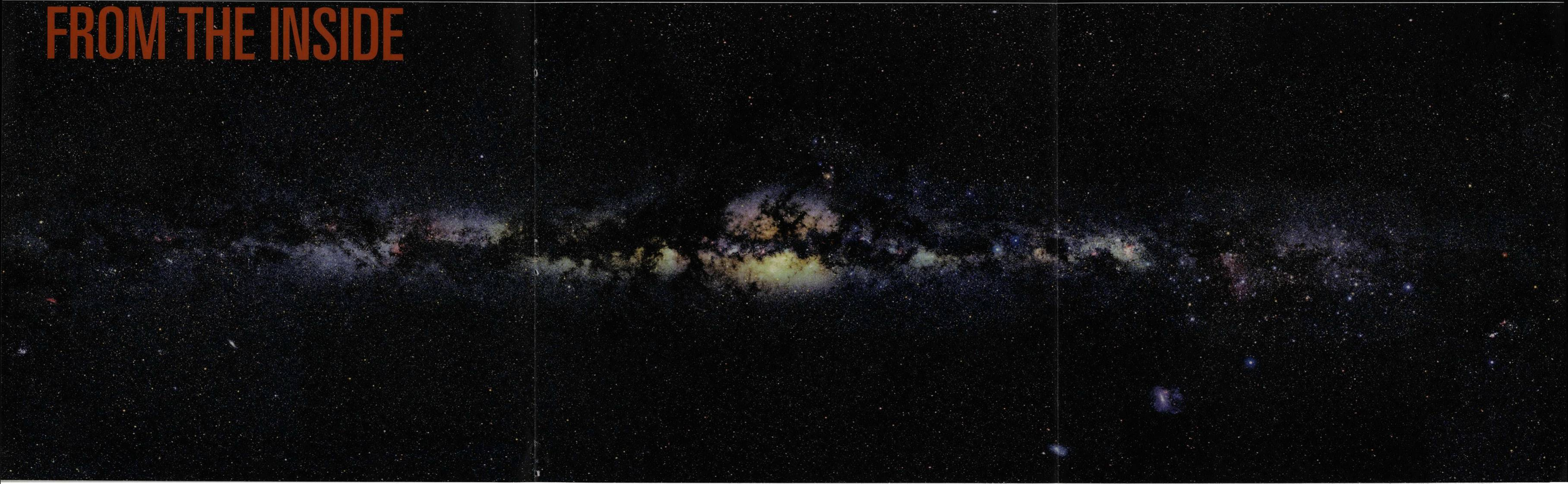
*Kelly Kizer Whitt, former copy editor of* Astronomy, *is a freelance writer and editor.*

# THE MILKY WAY FROM THE INSIDE

## An exceptional mosaic of deep exposures reveals the nature of our galaxy as we see it.

Text by Kelly Kizer Whitt • Photos by Axel Mellinger



**Axel Mellinger's impressive Milky Way panorama was created from the newfound ability of astronomers to do their "darkroom work" with sophisticated computer programs. Mellinger, an astronomer at the University of Potsdam, Germany, began experimenting with mosaic astrophotography in 1996. Faced with the limited resolution of film grain, he determined to weave images together and process them on a computer using digital imaging software. Mellinger employed a 28mm lens, Minolta SRT-101 or XD-5 camera, and Kodak PJM-2 and PJ-400 film to create 51 wide-angle images from observing posts in California's White Mountain Range and Cederberg Observatory in Southern Africa. Mellinger experimented with computer processing to eliminate distortions and create the so-called Aitoff projection view of the galaxy above, which renders the Milky Way in galactic coordinates. Numerous deep-sky objects of interest are littered along the Milky Way's disk, and are identified on a finder map on the reverse of this foldout. The result is a stunning depiction of the Milky Way as we see it from Earth's position.**

From any dark sky site, the sky during summer and winter evenings glows with the fuzzy light of millions of stars painted across the Milky Way. The galaxy's spiral shape spans 100,000 light-years but remains hidden to us because of our position within it, about two-thirds of the way out from the galactic center, in a sleepy part of the disk. Looking toward the galaxy's center — in the direction of Sagittarius — reveals not the Milky Way's center but only hints of the central concentration of stars and gas, the hub and nucleus lying hidden behind thick clouds of obscuring dust. But never mind — swarming with 200 billion stars and peppered with nearly countless nebulae and clusters, the Milky Way provides endless nights of observing for earthbound telescope and binocular users.

In an effort to capture a high-definition view of the Milky Way as we see it, in 1996 German astronomer Axel Mellinger set out to record a luxurious galactic panorama. "Three years and 51 wide-angle images later," Mellinger explains, "an all-sky panorama was completed." He used a 28mm lens at f/4 and exposures of 30 to 40 minutes on Kodak PJM-2 and PJ-400 film. The result is an extraordinary snapshot of the galaxy, rich with details and serving as a road map to many of the galaxy's most absorbing sights. One of the easiest features to spot is the Great Dark Rift, which severs the plane lengthwise between Cygnus and Sagittarius. The rift is a dusty cloud of tiny particles that obscures background stars. Other obscuring clouds, or dark nebulae, populate the Milky Way; most require superb transparency and a very dark sky to see when out under the stars.

Often, when observing, we forget how all-encompassing the Milky Way is to our view of the cosmos. Every object in

Details, details . . . The galaxy's center lies obscured from view by thick blankets of dust, but we see objects toward the core in Sagittarius (below). The Coal Sack and Southern Cross highlight one of the finest regions in the Southern Hemisphere sky (bottom left). For Northern Hemisphere viewers, Cygnus the Swan offers rich clouds of nebulae and dust (bottom right). Opposite page, bottom left: The galaxy rendered as an equidistant azimuthal (polar) projection separates the action into two hemispheres.

# Andromeda, Triangulum, and Aries

Artwork from *The Glorious Constellations*, © 1991; Harry N. Abrams, Inc.

## *The northern sky's finest galaxies make these autumn constellations backyard favorites.*

**by Tom Polakis**

With the days growing shorter and temperatures dropping, there's no question about it — autumn is in the air. That's good news for backyard observers, who welcome the longer nights and the often steady atmosphere this season brings. The calm air provides crisp views of the cornucopia of bright galaxies that populates the autumn evening sky.

This month we examine three constellations that lie along the southern fringe of the northernmost section of the Milky Way. Most prominent is Andromeda the Chained Princess, which radiates in two graceful arcs to the east and north of 2nd-magnitude Alpheratz (Alpha [α] Andromedae). Alpha serves double duty in the sky, also forming the northeastern corner of the Great Square of Pegasus. In fact, it once had the peculiar distinction of belonging to both constellations. The International Astronomical Union officially gave the star solely to Andromeda in the 1930s.

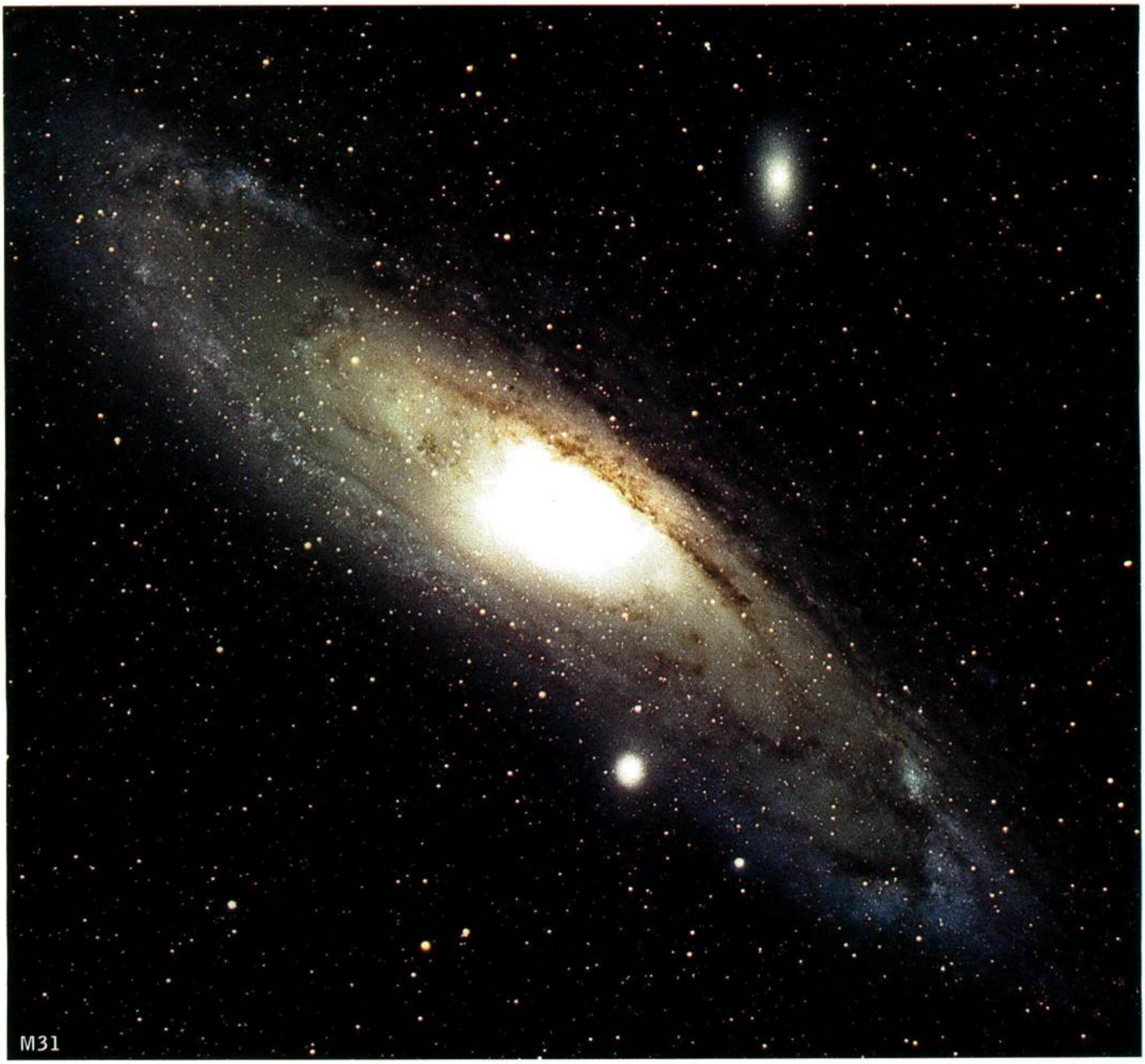
To the east of Andromeda dwells tiny Triangulum the Triangle, a thin isosceles triangle consisting of 3rd- and 4th-magnitude stars. And directly south of Triangulum lies Aries the Ram, anchored by the 2nd-magnitude star Hamal (Alpha Arietis).

Our telescopic tour of these constellations begins with **NGC 7640**, a nearby barred spiral located at the western edge of Andromeda. A 6-inch telescope shows only a slightly elongated core with a broad concentration. Doubling the aperture appears to double the galaxy's length, with faint wings extending to the north and south. Large regions of ionized hydrogen gas at the center impart a distinct mottling to the galaxy's appearance.

Swing your telescope 2° to the north-northeast and you'll land on the planetary nebula **NGC 7662**. It takes only one low-power view to understand how it earned its nickname, "The Blue Snowball." In an 8-inch scope, the object appears as a small, evenly illuminated disk with a faint central star. Larger instruments bring out rich inner structure. A hollow region immediately surrounds the 13th-magnitude central star, while a bright disk with prominent enhancements to the northeast and southwest encloses the hollow. A fainter, sharp-edged shell then surrounds this disk.

NGC 7662 lies about 3,000 light-years from Earth and formed roughly 8,000 years ago, when a sunlike star in its death throes puffed off its outer atmosphere. Long-exposure photographs reveal a feature this planetary shares with many others: a much larger, outer halo of extremely low surface brightness. This halo, beyond the reach of amateur scopes, extends more than 2' across and glows some 20,000 times fainter than the bright inner disk.

The highlight of Andromeda, and indeed of the entire autumn sky, is the **Andromeda Galaxy** (M31 or NGC 224), located just 1° west of the 5th-magnitude star Nu (ν) Andromedae. Its proximity to Earth and grand spiral structure makes this one of the most observed and studied galaxies in the entire sky. At a distance of just 2.4 million light-years, the brightest stars in M31 can be resolved in photographs taken through telescopes of modest aperture. In 1923 Edwin Hubble observed the changing light output of



George Greaney

Cepheid variable stars in the galaxy and determined its distance, proving once and for all that it was a distant "island universe." M31 has remained a must-see object for every new generation of instrument, including the space telescope named for Hubble.

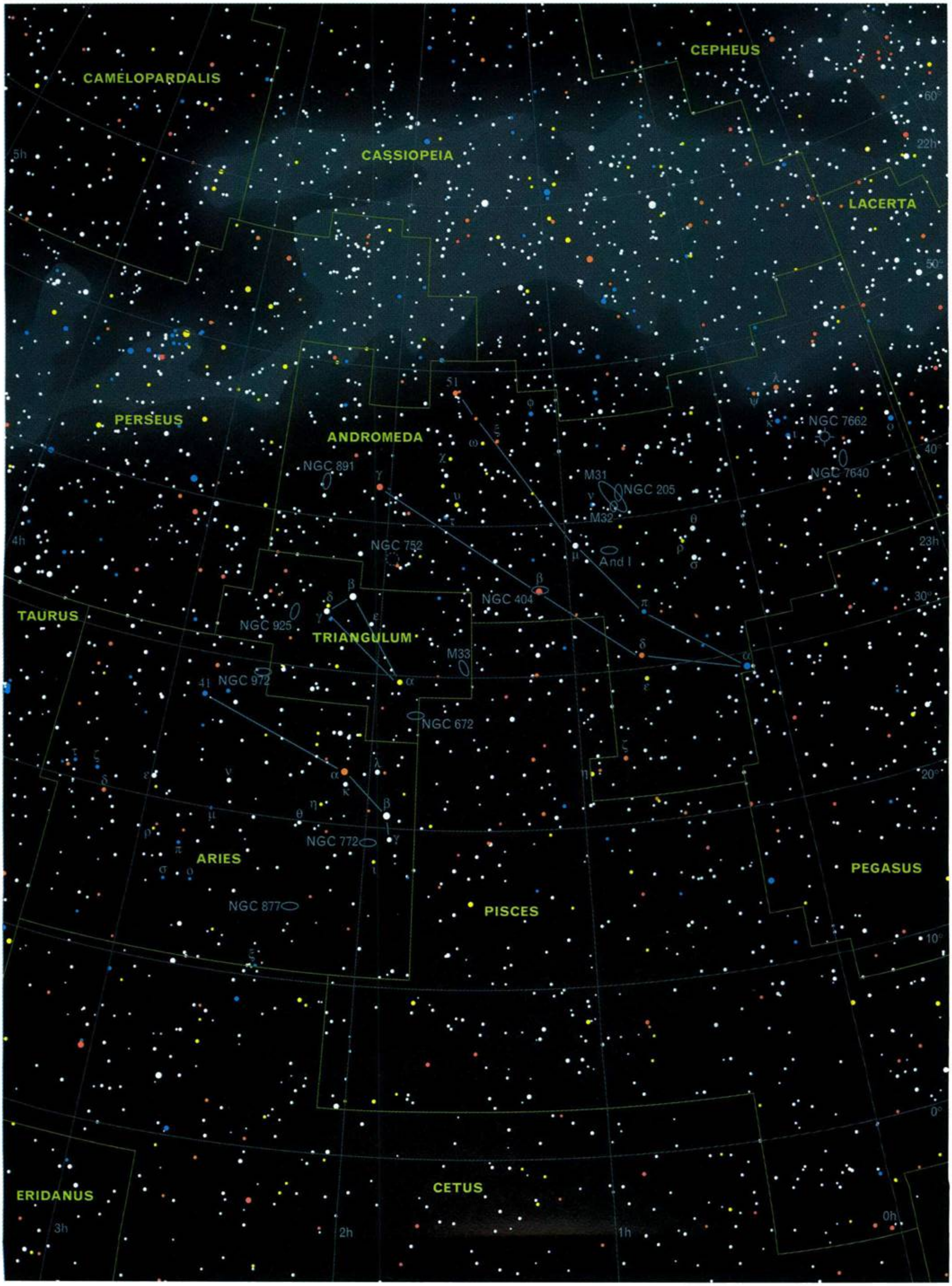
Observers can appreciate M31 even with the naked eye. From suburban sites, it resembles a distant galaxy seen through a telescope. From a light-polluted site that barely reveals the Milky Way, M31 appears about 1° long and a third as wide, with its long axis oriented northeast to southwest. At a dark site, it covers three times those dimensions, displaying a bright center and an outer halo that blends into the nearby starfields of the Milky Way.

Small telescopes can show the entire galaxy in a single field of view. With 6 inches of aperture, a prominent dust lane defines the western edge, while two lanes appear from a dark site. You'll also notice that the center brightens dramatically to a pinpoint nucleus.

Large telescopes can't capture M31 in one field, so the attraction becomes seeing the galaxy's individual components. The brightest of these is NGC 206, an association of young, hot stars on the southern end of the ring of spiral structure. A 10-inch scope brings out an elongated brightening, while a 20-inch stands a chance of resolving some of the association's brightest stars.

Experienced observers might want to try observing some of M31's brighter globular clusters. The largest of these appear distinctly nonstellar, showing disks as large as 10" in diameter. Located a full 2.5° southwest of M31's center is G1, the most luminous globular cluster in the Local Group of galaxies and some two times brighter than the Milky Way's champion, Omega Centauri. An excellent finder chart for these objects appears in Christian Luginbuhl and Brian Skiff's *Observing Handbook and Catalogue of Deep-Sky Objects*.

Less than half a degree due south of the heart of the Andromeda Galaxy lies a companion galaxy, **M32** (NGC 221). This relatively featureless elliptical appears 3' tall by 2' wide and shows a very hazy edge. Magnifications of


CAMELOPARDALIS
CEPHEUS
CASSIOPEIA
LACERTA
PERSEUS
ANDROMEDA
TAURUS
TRIANGULUM
ARIES
PISCES
PEGASUS
ERIDANUS
CETUS
NGC 7662
NGC 7640
NGC 891
M31
NGC 205
M32
NGC 752
And I
NGC 404
NGC 925
M33
NGC 972
NGC 672
NGC 772
NGC 877
51
41
5h
4h
3h
2h
1h
0h
22h
23h
60°
50°
40°
30°
20°
10°
0°

greater than 200x begin to resolve the barely nonstellar nature of its extremely bright core.

Also residing in the same low-power field with M31 is another elliptical companion, **NGC 205**. It bears little resemblance to M32, appearing nearly three times larger and much fainter. It exhibits a broad central concentration with no sign of a nucleus. Although long-exposure photographs made with observatory telescopes resolve the galaxy into stars, the brightest members glow at magnitude 18.5 and remain beyond the reach of backyard scopes.

Bob and Janice Fera

Three degrees south of the Andromeda Galaxy lies yet another companion, **Andromeda I**, but this one presents a challenge to even the most experienced deep-sky observers. Astronomers discovered this faint dwarf elliptical galaxy in 1972, along with two other faint M31 companions. Observations with the Hubble Space Telescope show it lies roughly 200,000 light-years from M31, similar to the distance of the Magellanic Clouds from the Milky Way. A 13-inch telescope at a dark site will barely show Andromeda I as a faint mist measuring 4' across. Sweep the telescope slowly across the target area to improve the galaxy's visibility.

Next head toward the southeast until you arrive at the 2nd-magnitude star Beta (β) Andromedae. The galaxy **NGC 404** forms a terrific pair with this star, lying just 7' to its northwest. This S0 galaxy — a type that has the disk shape of a spiral but no spiral arms — lies roughly 30 million light-years from Earth. Use high magnifications to increase the contrast between the galaxy and the bright star. NGC 404 appears round and bright and possesses an intense center. Enjoy viewing this disparate pair and don't fret over the glare created by the star — there isn't any detail to be seen in the galaxy.

The star at the eastern end of Andromeda's southern arc resolves into a gorgeous double when viewed in a small telescope. **Gamma (γ) Andromedae** features a 2nd-magnitude primary star with an orange hue and a 5th-magnitude bluish secondary located 10" away. A third component currently lies just 0.4" east of the 5th-magnitude star, but it's growing harder to see. The separation will close to less than 0.1" a decade from now. The challenging pair can be spotted with a 20-inch telescope, but seeing conditions need to be near perfect.

Pan 3.5° east from Gamma and you'll land on **NGC 891**, a stunning object that makes most everyone's list of favorite edge-on galaxies. Perhaps it's the galaxy's proximity to the Milky Way that creates such a pleasing view. Or maybe it's the nearly perfect edge-on view — it inclines just 1.4° to our line of sight — and beautiful symmetry that causes so many return visits. A 10-inch telescope reveals a streak about 10' long with a central bulge. A dark dust lane

## Deep-Sky Objects in Andromeda, Triangulum, and Aries

| Object | R. A. (2000.0) | Dec. | Mag. | Size/Sep. | Type | Notes |
|---|---|---|---|---|---|---|
| NGC 205 | 0h40.4m | 41°41' | 8.1 | 19.5' by 12.5' | Gal | E5 pec |
| M31 (NGC 224) | 0h42.7m | 41°16' | 3.4 | 185.0' by 75.0' | Gal | SA(s)b |
| M32 (NGC 221) | 0h42.7m | 40°52' | 8.1 | 11.0' by 7.3' | Gal | cE2 |
| And I | 0h45.7m | 38°00' | — | — | Gal | E3 pec |
| NGC 404 | 1h09.4m | 35°43' | 10.3 | 6.1' by 6.1' | Gal | SA(s)0 |
| M33 (NGC 598) | 1h33.9m | 30°39' | 5.7 | 67.0' by 41.5' | Gal | SA(s)cd |
| NGC 672 | 1h47.9m | 27°26' | 10.9 | 6.6' by 2.6' | Gal | SB(s)cd |
| Gamma Arietis | 1h53.5m | 19°18' | 4.6/4.7 | 7.8" | Dbl | |
| NGC 752 | 1h57.8m | 37°41' | 5.7 | 50' | OC | |
| NGC 772 | 1h59.3m | 19°01' | 10.3 | 7.3' by 4.6' | Gal | SA(s)b |
| Gamma Andromedae | 2h03.9m | 42°20' | 2.2/5.0 | 9.8" | Dbl | |
| NGC 877 | 2h18.0m | 14°33' | 11.9 | 2.1' by 1.7' | Gal | SAB(rs)bc |
| NGC 891 | 2h22.6m | 42°21' | 9.9 | 13.0' by 2.8' | Gal | SA(s)b |
| NGC 925 | 2h27.3m | 33°35' | 10.1 | 12.0' by 7.4' | Gal | SAB(s)d |
| NGC 972 | 2h34.2m | 29°19' | 11.4 | 3.4' by 1.6' | Gal | Sab |
| NGC 7640 | 23h22.1m | 40°51' | 11.3 | 10.0' by 2.2' | Gal | SB(s)c |
| NGC 7662 | 23h25.9m | 42°33' | 8.3 | 12" | PN | Blue Snowball |

**Object:** Designation in NGC or other catalog. **R. A. (2000.0) and Dec.:** Right ascension and declination in epoch 2000.0 coordinates. **Mag.:** Visual magnitude. **Size/Sep.:** Size in arcminutes or arcseconds; separation in arcseconds. **Notes:** Hubble type for galaxies.

# The Chained Princess

*"And Perseus saw her there, Andromeda, Bound to the arms to the rocks; her hair,*
*Stirred in a gentle breeze, and her warm tears flowing Proved her hot marble, as he thought, but woman."*
Metamorphoses, *Ovid (43 B.C.–A.D. 17)*

Andromeda plays a key role in perhaps the grandest of Greek myths, though the story apparently dates back to Babylonian times. No fewer than five prominent characters from the myth have been enshrined in the autumn sky.

The daughter of Cepheus the King and Cassiopeia the Queen, Andromeda was a fair princess seemingly without a care in the world. But Andromeda's fate was sealed by her mother, who apparently was more enthralled by her looks than a proper woman should be. Cassiopeia liked to boast that she was more beautiful than the sea nymphs, and eventually her vanity wore a little thin. The nymphs decided to ask their protector — Poseidon, the god of the sea — to help them get back at Cassiopeia.

Poseidon let loose a fearsome sea monster (Cetus the Whale) to ravage the kingdom. As the attacks grew worse, Cepheus implored an oracle for help. The unpleasant solution: Sacrifice their daughter to the monster by chaining her to a rock on the coast.

But millennia ago, gallantry was far from dead, and Perseus the Hero came to the rescue. Promised Andromeda's hand in marriage, Perseus killed Medusa, the only mortal of the three Gorgon sisters. Medusa, with snakes for hair, looked so hideous that anyone who gazed upon her turned to stone. Perseus cut off Medusa's head and brought it to the seacoast. When Cetus beheld the severed head, he instantly died, and Perseus gladly accepted his reward. — *Richard Talcott*

bisects the streak and runs nearly its entire length. Dozens of foreground stars pepper the field, adding to the visual impression.

Almost 5° south of Gamma Andromedae lies the large, bright open cluster **NGC 752**. From a dark site, the cluster shows up faintly to the naked eye amid the surrounding starfields. NGC 752 spans nearly a degree, so it looks best at magnifications below 50x. A pair of 11x80 binoculars gives a pleasing view of about 40 stars, all glowing near 10th magnitude. On the northern edge of NGC 752 rests the variable star DS Andromedae, an eclipsing binary that dims by half a magnitude from its usual value of 10.4 once a day. The variable lies approximately 1,400 light-years from Earth, placing it on the far side of the cluster.

NGC 772

James R. Foster

Look 4° west of 3rd-magnitude Alpha Trianguli, near that constellation's border with Pisces, to find the Local Group galaxy **M33** (NGC 598). At the darkest observing sites, M33 becomes a naked-eye object, particularly when it passes near the zenith as it does from mid-northern latitudes on autumn evenings.

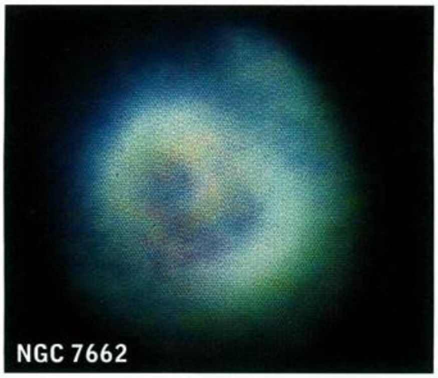
M33 looks like no other object when seen through a telescope. Although difficult to find from urban areas, M33 explodes into magnificent detail when observed from a dark site, with multiple spiral arms and several stellar associations coming into view. In a 10-inch telescope at 50x, the galaxy shows an overall S-shape that surrounds a subtly brighter center. Large stellar groupings tend to confuse this elegant form, however. These vast conglomerations, the equivalent of the Milky Way's Scutum and Norma star clouds, appear as large, uniform glowing patches just away from the galaxy's main body.

Before leaving M33, take a minute to search for the emission nebula NGC 604. Arguably the finest object visible in any external galaxy in the northern sky, this region of ionized hydrogen lies at the tip of M33's northern spiral arm. A 13-inch telescope at 300x shows two tiny lobes in contact, not bad for a view from some 2.2 million light-years away. It appears to blink in and out of view when observed at low power alternately with and without a nebula filter.

Let the figure of Triangulum point you to **NGC 672**, a barred spiral galaxy that's interacting with its neighbor, IC 1727. Both lie 26 million light-years from Earth and show up in the same high-power field. NGC 672 appears 5' long and elongated east to west, with only a subtle brightening in the center. IC 1727 glows much fainter and looks diffuse with a hazy central bar.

NGC 925

Kim Zussman



NGC 7662

Jack Newton

Sweep 2° east of Gamma Trianguli and you'll find another barred spiral, **NGC 925**. In a small telescope, it looks like an elongated smudge, but a large backyard scope reveals spiral arms that fold back abruptly from a long bar. High magnifications will let you see the galaxy's stellar nucleus.

Just across the border into Aries lies the diminutive galaxy **NGC 972**. Although classified as a normal spiral, it shows what astronomers describe as a "mini-bar" at the center. In a typical amateur instrument, however, it appears as a bright, small oval surrounded by an outer halo. Look for a string of three dim foreground stars south of the galaxy, each a magnitude fainter than its neighbor.

The western tip of Aries the Ram is marked by the double star **Gamma Arietis**. To the naked eye, the system appears as a single star shining at magnitude 3.9. But even a small telescope at 50x reveals two components of virtually equal magnitude. One star lies 7.6" directly north of the other.

A little more than a degree east of Gamma you'll find the spiral galaxy **NGC 772**. Through a 13-inch scope, it shows a bright central core surrounded by a haze that extends some 3'. In large observatory instruments, however, NGC 772 shows a distorted northern spiral arm. That landed it as the 78th entry in Halton Arp's *Atlas of Peculiar Galaxies*, a compilation of galaxies with unusual structure often resulting from interactions. The culprit in this case seems to be the elliptical galaxy NGC 770, whose bright center can be seen easily just off the southern edge of NGC 772's halo.

Our final stop on this month's tour lurks in southern Aries. **NGC 877** ranks as the brightest member of a tight galaxy group located some 175 million light-years away. At high magnification, the small spiral shows a bright central bar inside a broadly concentrated core. Just to its southwest lies the extremely faint, edge-on spiral NGC 876. Several more galaxies appear to the west in this same high-power field, with the brightest of these being the barred spiral NGC 871.

NGC 404

John Chumack

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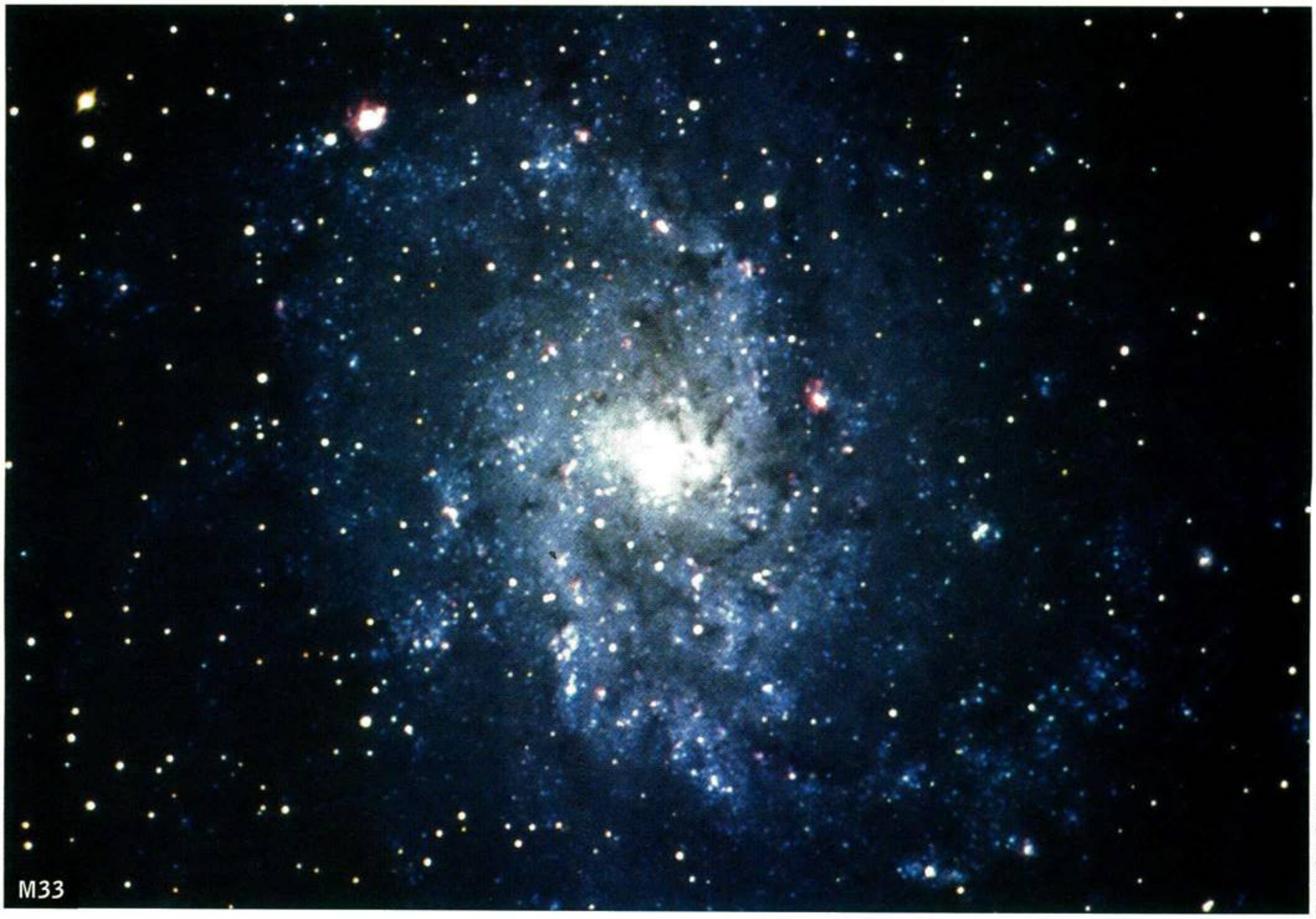
*Tom Polakis is an aerospace engineer living in Tempe, Arizona. His favorite astronomical pursuits are deep-sky observing and photography.*



M33

Bill and Sally Fletcher

# sky Show

## november

**Leonids storm across the sky.**

by Martin Ratcliffe and Alister Ling

▶ From their icy birthplace on Comet Tempel-Tuttle, legions of dust particles are lining up to blaze fiery trails across our skies. A fury of falling stars will shoot across the heavens, the likes of which have not been witnessed since the 1966 Leonid meteor shower.

Thousands of meteors will streak through the silent stillness of the sky on the morning of November 18. The storm surge is expected to hit at night for Australasia and reserve a good squall for the Western Hemisphere a few hours later. Meteor counts are likely to range from a couple hundred per hour over the Americas to a few thousand per hour on the other side of the world. Ringside seats are available anywhere the skies are dark and clear. Luckily, the peak arrives on a weekend free of the moon's interfering light.

Urban skywatchers have lots to view this month. Mercury caps off its best morning apparition of the year with a tight slide past brilliant Venus in the first week of November. Then there's the return of the gas giant planets to the evening sky. From the serene shadow samba of Jupiter's moons to the enrapturing rings of Saturn and its dainty moon dance, something interesting is always happening.

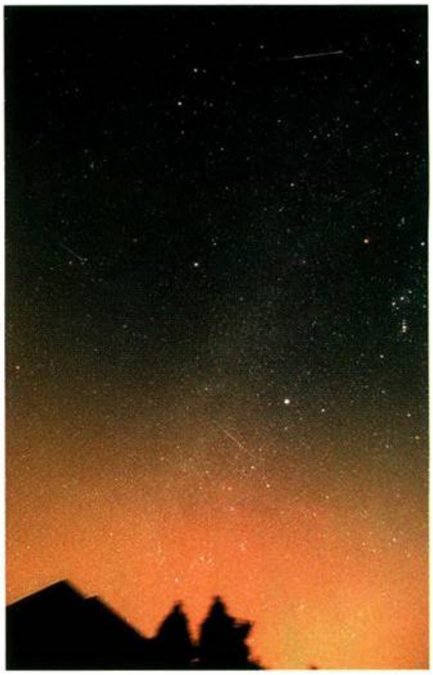
Don't forget to give an extra treat to the kids (and parents) on Halloween night by setting up your scope for some sidewalk astronomy. The bright full moon may show off some of its many craters splashed out from prehistoric impacts, but Saturn is a guaranteed showstopper for ghouls and goblins.

If you're new to stargazing and want to see a nice comet, head out of town to catch LINEAR WM1 as it glides across the eastern sky. It should temporarily satisfy your appetite during our wait for the next big one. Best seen mid-month around midnight, this dirty snowball should be readily visible in binoculars. If we're lucky, it will be seen with unaided eyes in December.

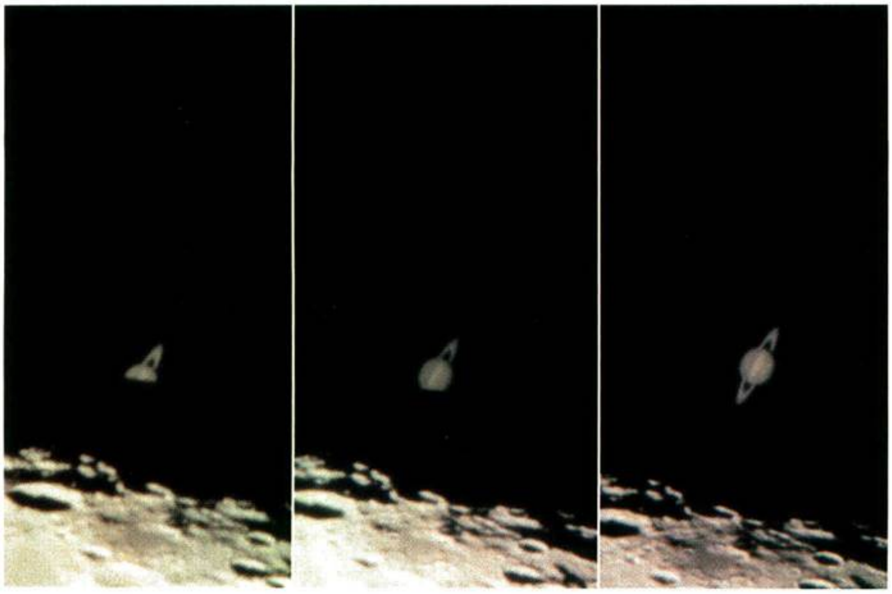
Now is also the time to find Uranus and Neptune, with a little help from Mars. The orange-colored Red Planet is 2.2° due south of Neptune on the 4th, and 0.8° south of Uranus on the 26th. Watch how Mars continues to beat a hasty retreat eastward against the stars while fading to magnitude zero.

Cross your fingers if you want to watch the moon seemingly swallow up Saturn. Most skygazers consider this a rare event, thanks to the vagaries of weather. An occultation, in which one celestial object of larger apparent diameter partially or completely obscures another, occurs twice this month but is only visible on opposite sides of Earth. From Europe to Japan, Saturn slips behind the moon on the 3rd. North Americans can catch the second occultation on the evening of November 30.

Observers positioned in western Canada will see Saturn just move past the edge of the moon but the Ringed Planet will remain in full view.



**Leonid meteors streak over Brooksville, Florida, in 1998.** Mark Schroeder



**Saturn emerges from a lunar occultation in September 1997.** Chris Cook

# 2001
# November

1 Full moon is at 12:41 A.M. EST

2 Mercury passes 5° north of Spica, 4 A.M. EST
Venus passes 4° north of Spica, 7 A.M. EST
Jupiter is stationary, noon EST

3 The moon passes 0.6° north of Saturn, 5 P.M. EST

4 Mars passes 2° south of Neptune, 1 P.M. EST

6 The moon passes 1.7° north of Jupiter, 2 A.M. EST

8 Asteroid Julia is at opposition, 3 A.M. EST
Last quarter moon is at 7:21 A.M. EST

11 The moon is at perigee (228,203 miles from Earth), 12:25 P.M. EST

15 New moon is at 1:40 A.M. EST

18 Leonid meteor shower peaks (page 78)

20 Asteroid Parthenope is at opposition, 6 A.M. EST
The moon passes 3° south of Neptune, 4 P.M. EST

21 The moon passes 3° south of Mars, 2 P.M. EST
The moon passes 4° south of Uranus, 9 P.M. EST

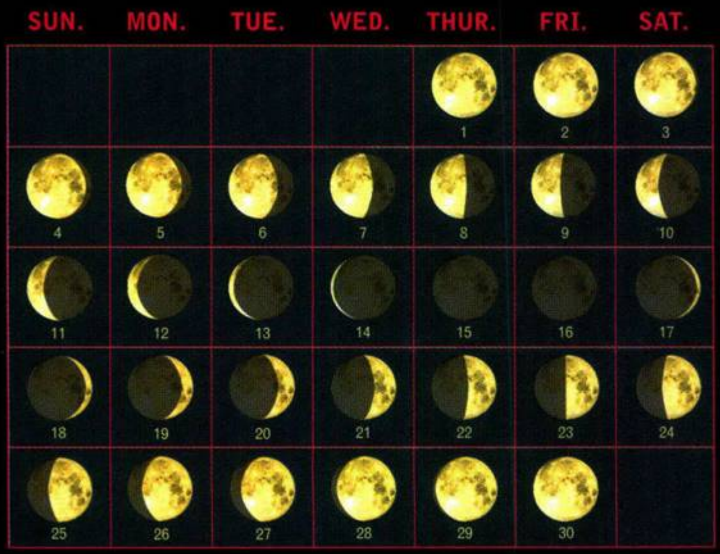
22 First quarter moon is at 6:21 P.M. EST

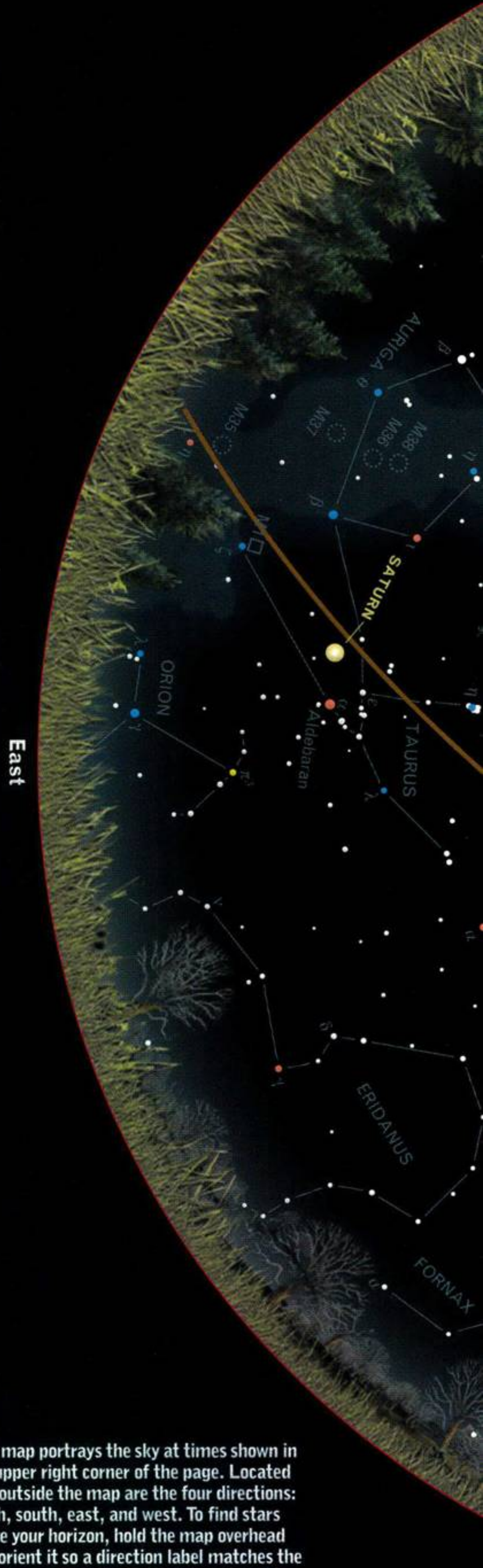
23 The moon is at apogee (251,279 miles from Earth), 10:46 A.M. EST

26 Mars passes 0.8° south of Uranus, 5 A.M. EST

27 Asteroid Vesta is at opposition, noon EST (page 79)

30 Full moon is at 3:49 P.M. EST
The moon passes 0.5° north of Saturn, 9 P.M. EST (page 77)

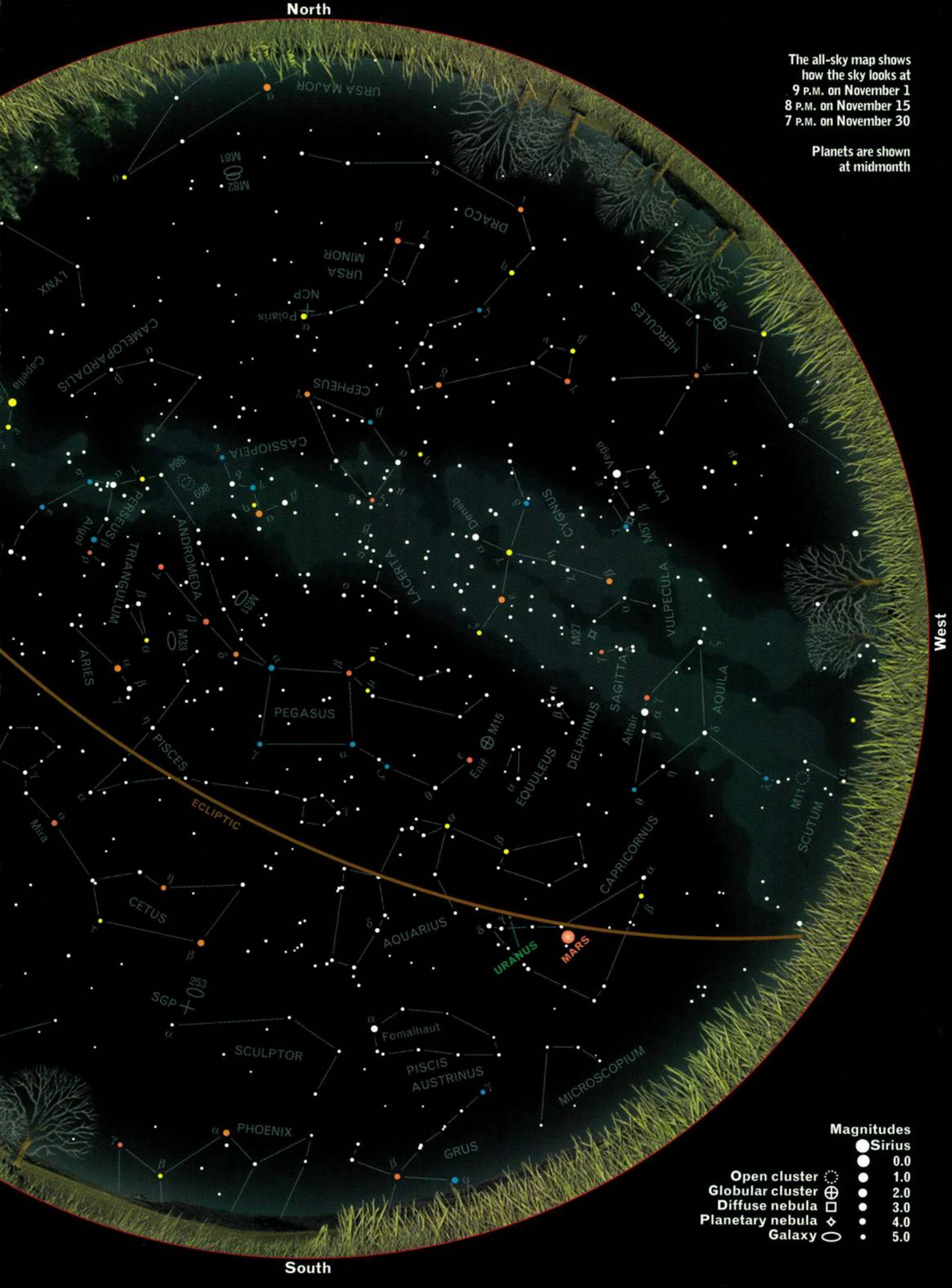




This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

The all-sky map shows
how the sky looks at
9 P.M. on November 1
8 P.M. on November 15
7 P.M. on November 30

Planets are shown
at midmonth

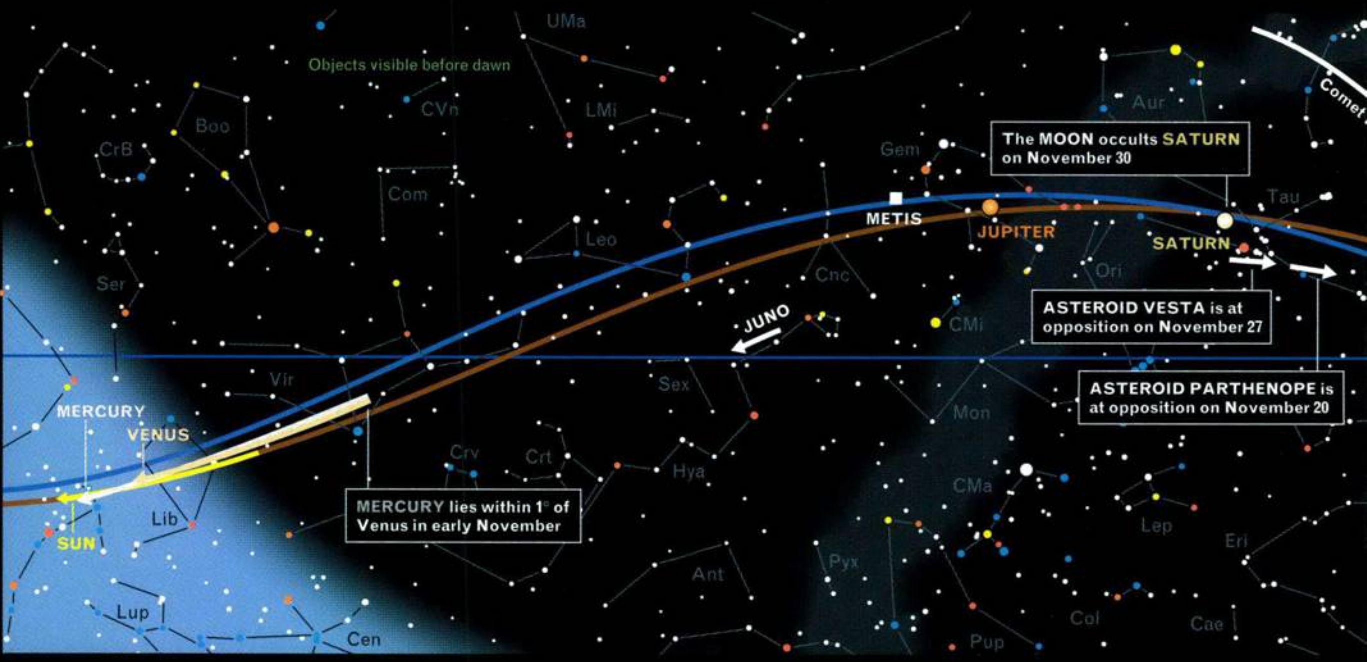

North
South
West
URSA MAJOR
M81
M82
DRACO
URSA MINOR
NCP
Polaris
LYNX
CAMELOPARDALIS
Capella
CEPHEUS
CASSIOPEIA
884
869
PERSEUS
Algol
ANDROMEDA
M31
TRIANGULUM
M33
ARIES
LACERTA
Deneb
CYGNUS
Vega
LYRA
M57
HERCULES
M13
VULPECULA
M27
SAGITTA
AQUILA
Altair
DELPHINUS
EQUULEUS
PEGASUS
M15
Enif
PISCES
ECLIPTIC
Mira
CETUS
SGP
253
AQUARIUS
URANUS
MARS
CAPRICORNUS
SCUTUM
M11
SCULPTOR
Fomalhaut
PISCIS AUSTRINUS
MICROSCOPIUM
PHOENIX
GRUS

**Magnitudes**
Sirius
0.0
1.0
2.0
3.0
4.0
5.0

Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

# Path of the Planets

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system object



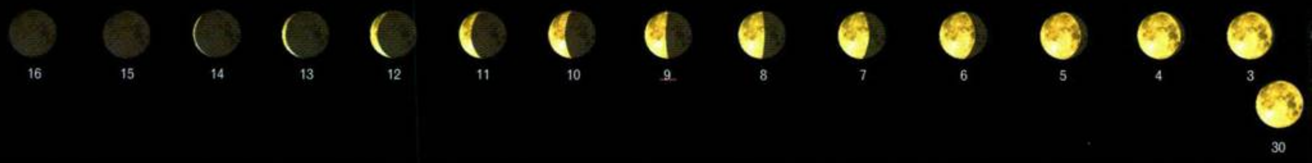
Objects visible before dawn
UMa
CVn
LMi
Boo
CrB
Com
Leo
Ser
Vir
Sex
Cnc
Gem
Aur
Tau
Ori
CMi
Mon
CMa
Lep
Eri
Pyx
Ant
Col
Cae
Pup
Hya
Crv
Crt
Lib
Lup
Cen
MERCURY
VENUS
SUN
JUNO
METIS
JUPITER
SATURN
Comet

The **MOON** occults **SATURN** on **November 30**

**ASTEROID VESTA** is at opposition on **November 27**

**ASTEROID PARTHENOPE** is at opposition on **November 20**

**MERCURY** lies within 1° of Venus in early **November**



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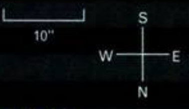
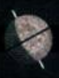
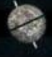
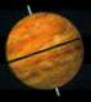
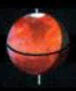
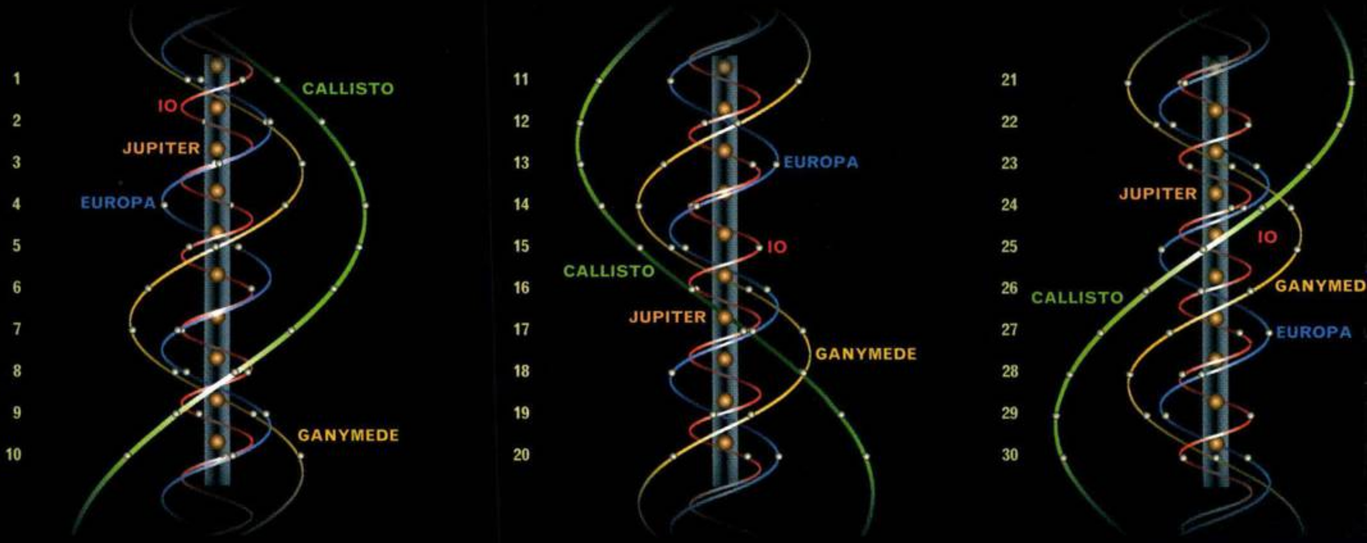


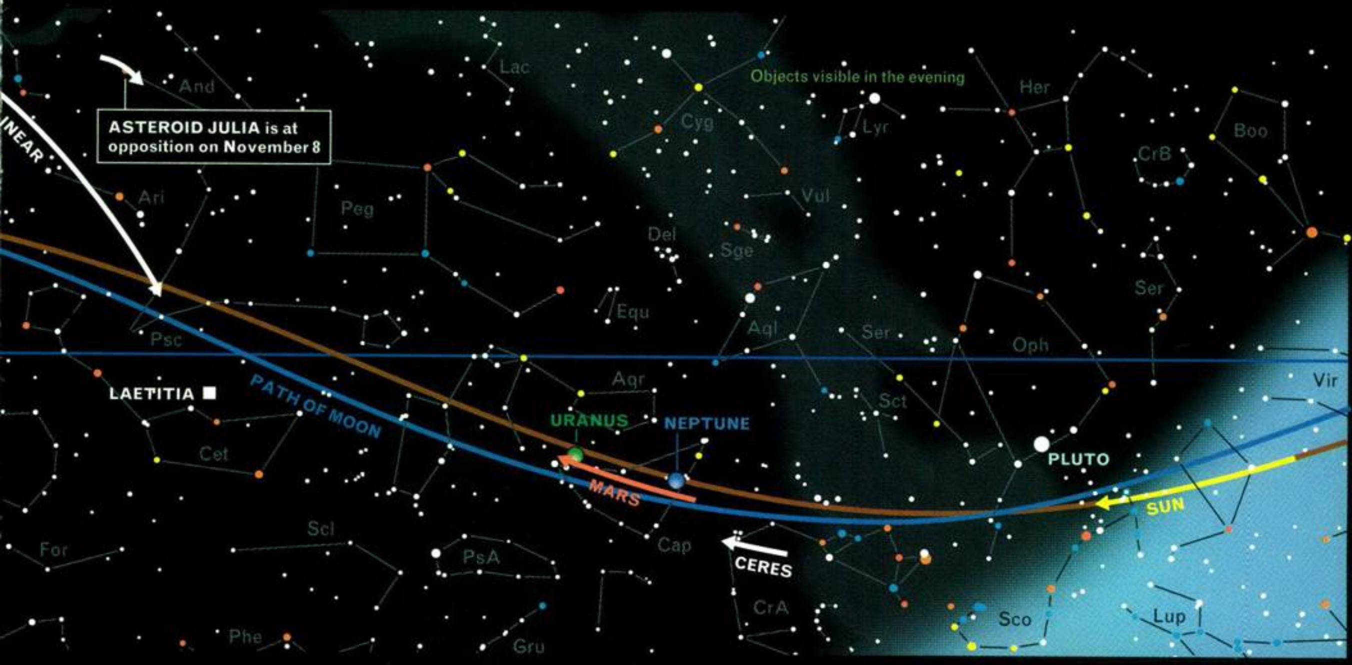
| **PLANETS** | **MERCURY** | **MERCURY** | **VENUS** | **MARS** | **JUPIT** |
|---|---|---|---|---|---|
| **Date** | November 1 | November 15 | November 15 | November 15 | Novemb |
| **Magnitude** | −0.7 | −0.8 | −3.9 | 0.2 | −2.5 |
| **Angular Size** | 6.4" | 5.1" | 10.2" | 8.1" | 43.9 |
| **Illumination** | 66% | 94% | 97% | 86% | 99% |
| **Distance (AU) from Earth** | 1.046 | 1.324 | 1.633 | 1.161 | 4.49 |
| **Distance (AU) from Sun** | 0.328 | 0.405 | 0.721 | 1.390 | 5.15 |
| **Right Ascension (2000.0)** | 13h18.8m | 14h36.9m | 14h24.4m | 21h02.9m | 7h06. |
| **Declination (2000.0)** | −5°59' | −14°00' | −12°59' | −18°40' | 22°2 |
| |  |  |  |  | |

# Jupiter's Moons

Dots display positions of Galilean satellites at 4 A.M. EDT on date shown. South is at top to match the view in a telescope.



during the month.


Objects visible in the evening
ASTEROID JULIA is at opposition on November 8
INEAR
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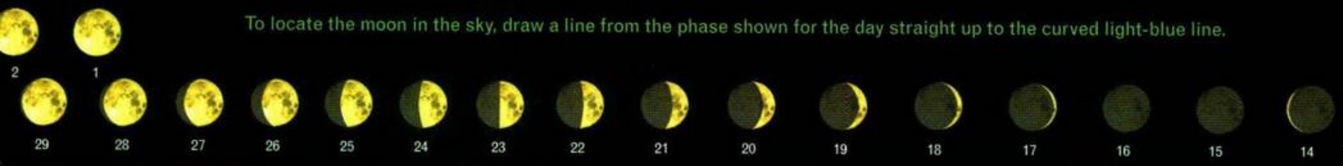
LAETITIA
PATH OF MOON
Aqr
Sct
Vir
URANUS
NEPTUNE
PLUTO
Cet
MARS
SUN
Scl
Cap
CERES
For
PsA
CrA
Sco
Lup
Phe
Gru

To locate the moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.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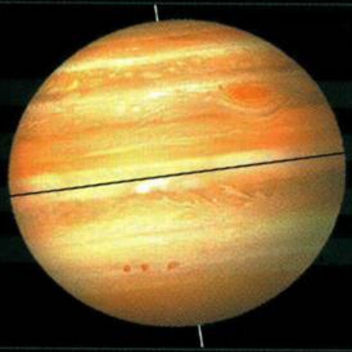
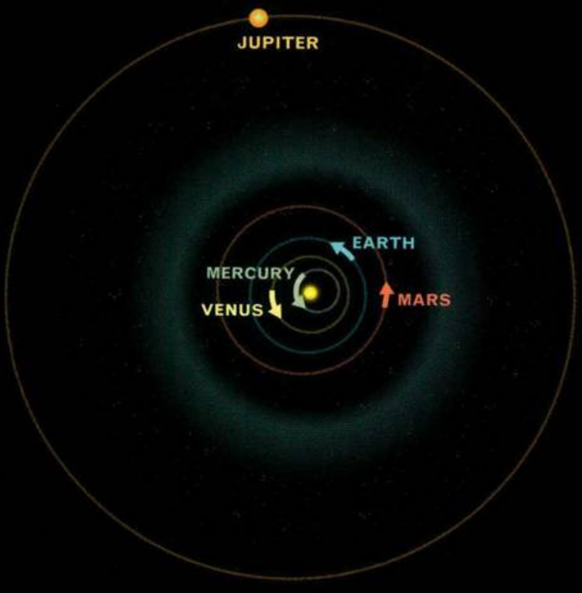
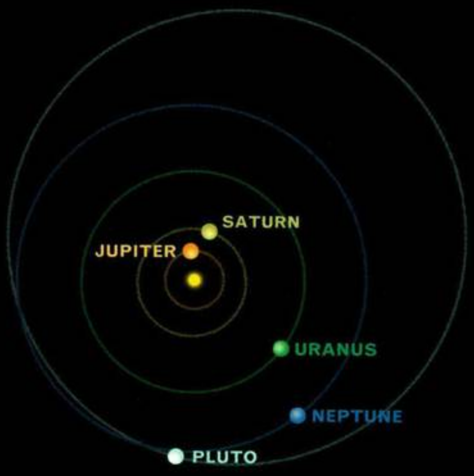


| ER | SATURN | URANUS | NEPTUNE | PLUTO |
|---|---|---|---|---|
| r 15 | November 15 | November 15 | November 15 | November 15 |
|  | −0.3 | 5.8 | 7.9 | 13.9 |
|  | 20.4" | 3.5" | 2.2" | 0.1" |
|  | 100% | 100% | 100% | 100% |
|  | 8.134 | 19.989 | 30.363 | 31.348 |
|  | 9.068 | 19.984 | 30.097 | 30.444 |
| m | 4h47.0m | 21h34.5m | 20h34.2m | 16h56.3m |
|  | 20°29' | −15°11' | −18°37' | −12°45' |

## The Planets in Their Orbits

Arrows and dots show planets' positions during the month.


JUPITER
EARTH
MERCURY
MARS
VENUS


SATURN
JUPITER
URANUS
NEPTUNE
PLUTO

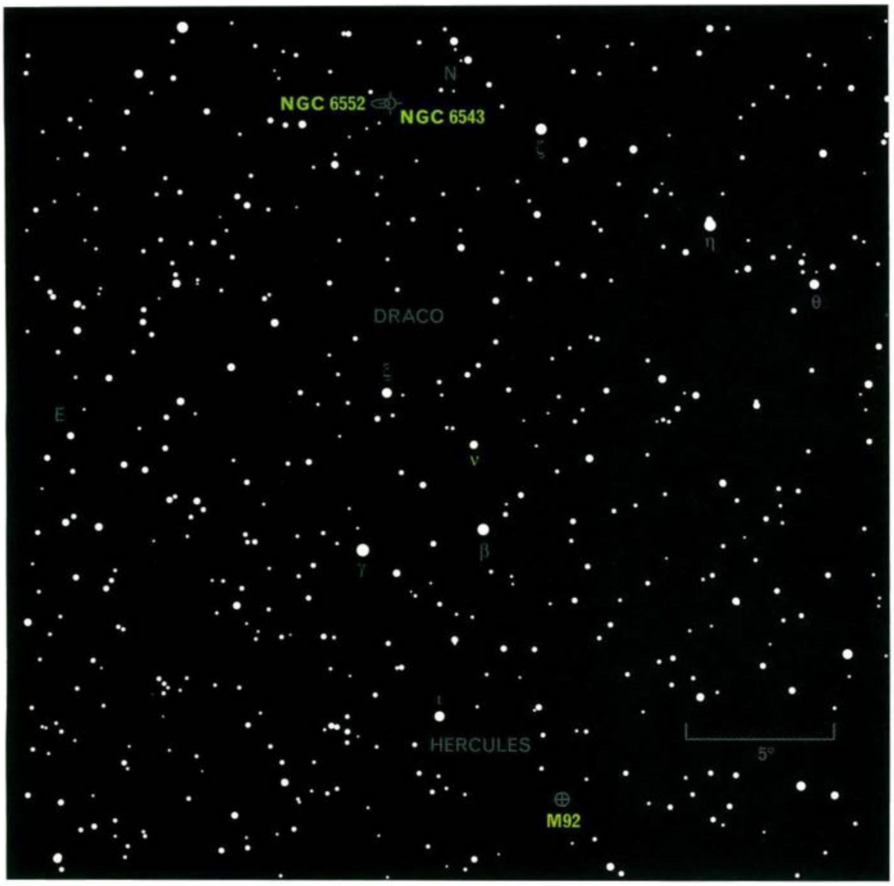
### In the Dragon's Lair

Within reach of Draco's flaming breath lie a stellar emerald and a ball of fire. Plenty of prizes here reward both casual adventurers and tireless observers. From a suburban backyard you should be able to see Draco's eyes hanging halfway up the western sky, to the lower right of the brilliant blue-white star Vega. Using wide-angle binoculars, you can capture Draco's entire head. It's formed by four stars in the shape of a slightly crumpled box, the most striking feature of which is the lower right star Nu (ν) — actually…a pair of stars. You'll need to limit jiggling to resolve them, so try leaning against a wall or propping your elbows on the roof of a car to steady the view.

Through a small telescope, Nu Draconis reveals a striking set of twins. Its wide separation, 62", is quite uncommon. Nu is a good double star for beginners; both stars are white and equally bright. For a pleasant change, swing over to Albireo at the foot of the cross in Cygnus.

Follow the bottom of Draco's square head to the lower left by about three of its lengths and your binoculars will reveal a fuzzy "star." This is the globular star cluster M92 (NGC 6341), a swarming mass of hundreds of thousands of stars. An 8-inch scope resolves the cluster's brightest stars, which surround the central glow.

In a smaller scope, M92's nature is hidden from direct view, as it mimics a large, round cotton ball, just like the one Charles Messier saw more than 200 years ago. As it turns out, another keen observer, Johann Bode, discovered M92 in 1777. Bode is best remembered for his law concerning the spacing of the planets.



**Globular cluster M92** is a cotton ball-like mass of thousands of stars. Bill Iburg

Nestled in the first curve of Draco's neck lies an observational emerald, NGC 6543 — its nickname is the Cat's Eye Nebula. NGC 6543 is one of the few deep-sky objects that are recognizably green. An 8-inch scope pulls in enough light to make it look almost traffic-light green. To best see its color, you have to look straight at it, because most of your eye's color receptors, or cones, are in the center of the retina. In contrast, your eyes' faint-light receptors, rods, are concentrated to the sides of the retina, which explains why glancing to the side makes faint objects appear brighter.

Compare the Cat's Eye to Uranus, currently in Capricornus, low in the south, to see why NGC 6543 is called a planetary nebula — its disk looks a bit like a gas giant planet. But that's where the similarity ends. Planetaries are shells of gas ejected during a star's dying years, fluoresced into visibility by the remnant, white-hot stellar core.

Anytime you have access to a large scope, keep returning to NGC 6543 until the night is steady enough for you to examine it at magnifications of more than 300x. The bright central star becomes distinct, while the nebula itself begins to show some arcing structure as shown so beautifully in Hubble Space Telescope images.

Seasoned observers who probe the very depths of the sky may want to seek the diminutive NGC 6552, a 14.7-magnitude background galaxy only 9' east of the Cat's Eye. If you like observing at the edge of your abilities, check the web for new ideas at http://groups.yahoo.com/group/amastro.

# sky Show

## Saturn Disappears Behind the Moon

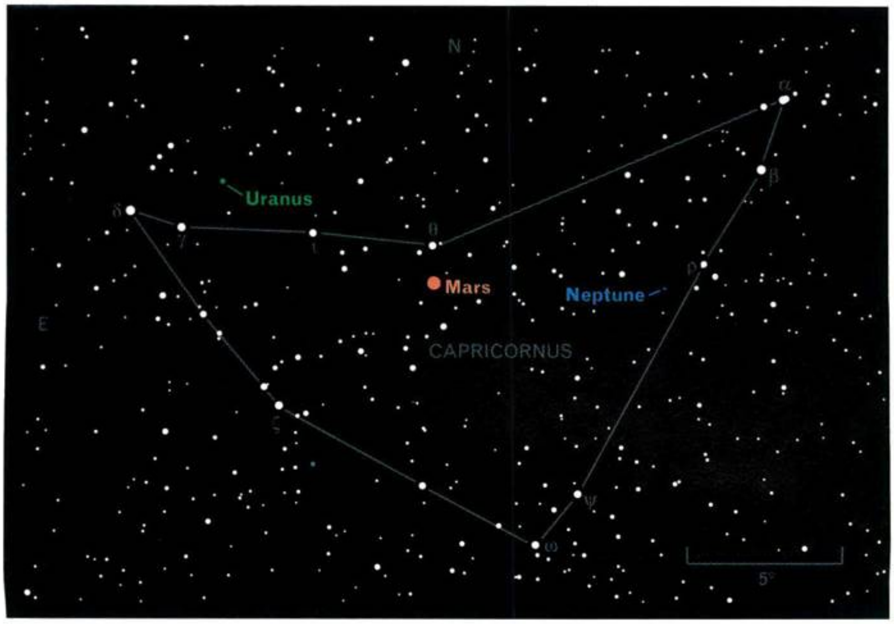
Engage yourself this month with a spectacular view of the Ringed Planet, **Saturn**. It floats in the eastern sky shortly after sunset. Saturn is approaching its best appearance in years and reaches opposition next month. Jupiter rises shortly after Saturn and provides a giant-planet spectacle during early evenings in late autumn. In the western sky, Mars, Uranus, and Neptune gather in Capricornus, although each of these planets will soon disappear into the twilight glow of the sun.

**Mars**, once brilliant in the summer sky, has gradually faded over the past four months and now shines two magnitudes fainter than during its June opposition. However, by the end of November Mars stands out prominently as the brightest object in Capricornus (at magnitude 0.4) and sets five hours after the sun. On November 4 Mars lies 2.1° south of **Neptune**. To spot magnitude-7.9 Neptune, you'll need assistance from binoculars or a small telescope.

Mars continues its easterly path across Capricornus, passing 0.9° south-southwest of **Uranus** on November 25. The Mars/Uranus pair will be beautiful through binoculars or at low power in a telescope. The greenish-blue disk of Uranus contrasts nicely with the rusty red glow of Mars. The disk of Uranus spans a mere 4' and is far too small to show any details in its cloud deck. Mars is also too small to yield any details, yet it is double the apparent size of Uranus due to its proximity to Earth.

Two hours after sunset, when the sky is nice and dark, Saturn shines brilliantly in the eastern sky and rises higher with each hour. It outshines Aldebaran and lies midway between the two horns of Taurus the Bull. On the evening of November 3, in the Americas, Saturn lies 3° west of an almost full moon. For European observers, a spectacular occultation of Saturn by the moon occurs on the same evening. The event is visible as far east as Japan. Using a telescope, observers will see the rings slowly disappear behind the bright limb of the moon, followed shortly by the disk. Large telescopes will also show the disappearance of the largest moon, Titan. Within an hour, Saturn will reappear from behind the dark limb of the moon.

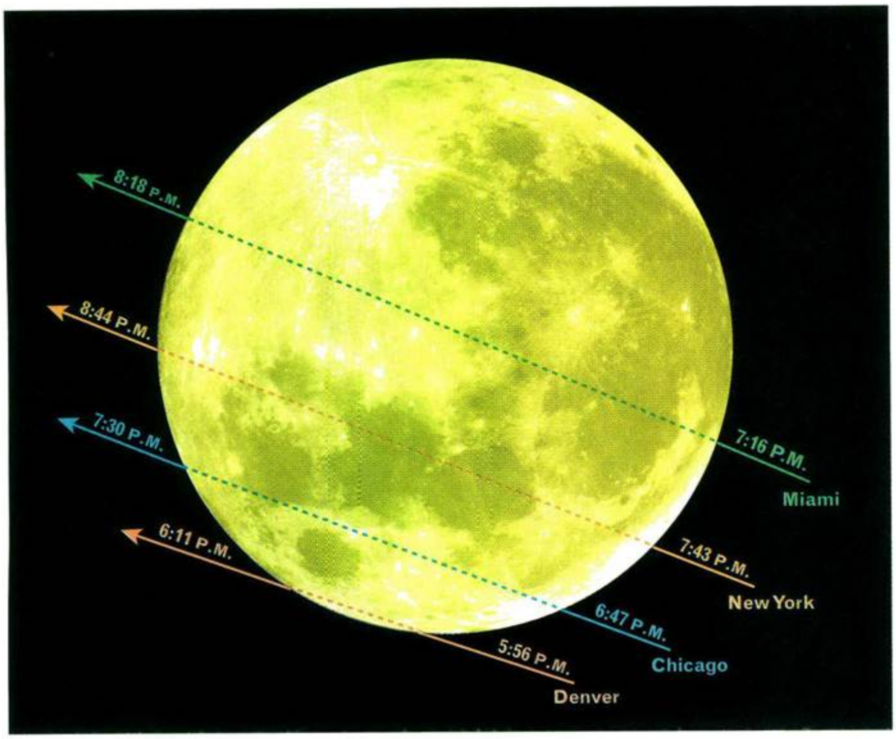
North American observers will get a chance to view a lunar occultation of Saturn on November 30. This early evening event is visible for eastern and central regions of the United States. Only the reappearance is visible from the West Coast. For the rest of the country, the moon rises when it is very near Saturn. So make sure you have a clear eastern horizon to view it. Watch carefully as the moon gradually creeps up on Saturn. Viewing the occultation will require a telescope — the moon's incredible brilliance compared to Saturn's relatively dim glow makes seeing the disappearance a challenge. If you miss this event, you'll get another chance next month on December 28.

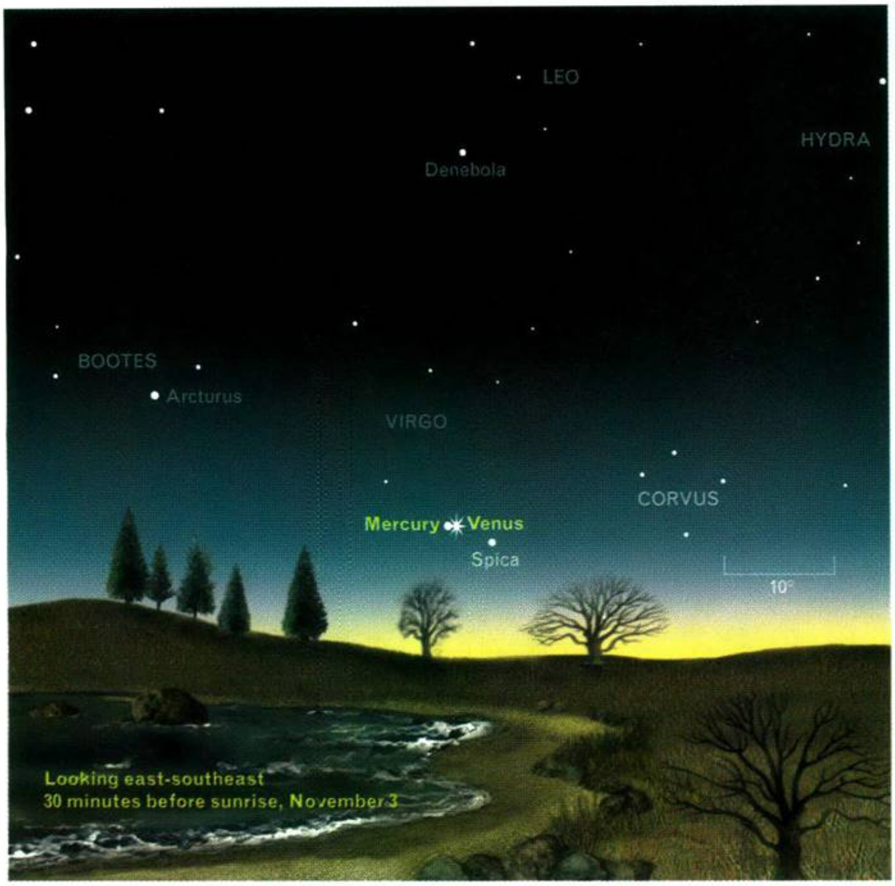


**The King of the Gaseous Giants appears in all its splendor.** Steve Lantz

**Jupiter** rises two hours after Saturn. Once Taurus is high over the eastern horizon look to the east-northeast for the brilliant glow of Jupiter as it moves within the stars of Gemini the Twins. Jupiter will not reach opposition until next year, but its large size and great brilliance mean that observers can see significant detail on the planet any time it is visible. During November, Jupiter reaches magnitude –2.6 and spans 45" across. Any 60mm telescope will reveal the planet's dark equatorial belts; patient observers will be able to pick out finer details. Of course, larger telescopes show a greater range of detail. Drawing the planet can build a familiarity with its cloud features so that subtle changes become obvious. Practice sketching its cloud details over a few nights to see for yourself. Also check out the regular occultations and eclipses of Jupiter's moons.

Observe Jupiter and Saturn all night until they begin to sink toward the





Looking east-southeast
30 minutes before sunrise, November 3

western horizon during the early morning hours, when the two inner planets of the solar system, **Mercury** and **Venus**, make a brief and spectacular appearance.

As November begins, Mercury and Venus lie less than 40' apart — equal to just a little more than one moon width. Arcturus, in Boötes the Herdsman, will be standing above the east-northeastern horizon as the pair of planets peeks over the eastern horizon shortly after 5 A.M. CST. The two planets are closest on the morning of October 29. Mercury is currently coming to the end of its best morning apparition of the year. Venus is easy to spot at a brilliant magnitude of –3.8. Mercury is a respectable magnitude –0.7. Spica, the brightest star in Virgo, lies just to the right of the duo for a few days in early November.

Mercury and Venus move quickly toward the sun's twilight glow. They remain within two moon widths through November 5, but Mercury falls from view soon after. Venus lies almost 8° below a slim crescent moon on November 13 and may be glimpsed in binoculars or with the naked eye. However, Mercury will lie an additional 2° below Venus at this time and will be nearly impossible to see.

Both planets are traveling toward the opposite side of the sun from Earth, and consequently exhibit an almost full phase. Venus appears as a small 10"-diameter disk through a telescope as it shimmers due to atmospheric turbulence. In 1610, Galileo used his first astronomical telescope to view a full-phased Venus and realized the folly of Ptolemy's Earth-centered system, which had persisted for more than a thousand years. If the Ptolemaic system were correct, Venus could only exhibit a thin crescent at any time during its orbit. Clearly, Galileo's evidence proved that it did not. Such a simple observation combined with a little geometry revolutionized humanity's view of the solar system. We lose the chance to see Venus in the morning sky by mid-November, but it will slowly return to the evening sky in 2002.

# Meteors and Moons

### The Leonids, at Long Last

This year's long-awaited Leonid meteor shower is a must-see.

A pair of astronomers from the Armagh Observatory in Northern Ireland correctly predicted the great Leonid meteor show of 1999 and the lack of a great display in 2000. Given this excellent track record, skywatchers are confident in the duo's prediction that a major storm may occur in November 2001. The storm, if it does occur, will result from Earth passing through streams of locally dense meteoritic debris during the early hours of November 18. The two streams were deposited along the orbit of the parent comet Swift-Tuttle in 1699 and 1866. The 1866 material is more recent and likely to be more concentrated, resulting in a brief but fierce storm of meteors. The astronomers predict that this trail will be reinforced by the 1699 trail. With a nearly new moon in the sky, conditions are perfect for a storm of historic proportions.

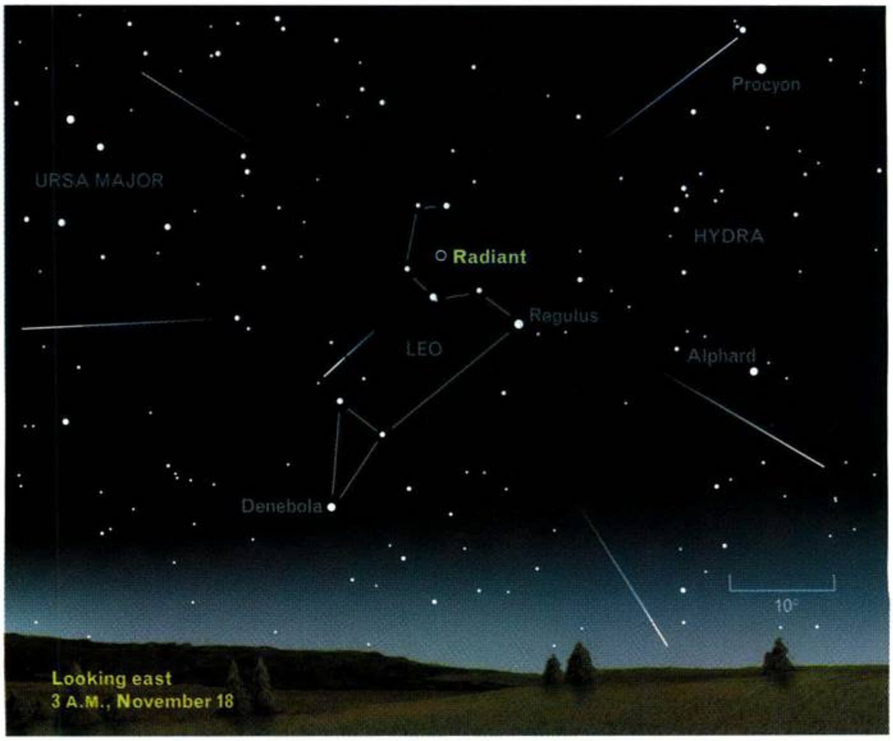
Of course, timing is the most critical thing, since only those observers on Earth who are in darkness and on the leading, early morning side of our planet will get to see the event. The predictions indicate that a major storm might occur over eastern Asia and Australasia, with a secondary event visible from the Americas. This means that most of the United States could see a reasonable amount of activity, but only those individuals prepared to travel to the other side of the world are likely to see the major storm — if it happens. Because meteor-shower prediction is in its infancy, the potential for disappointment is considerable. The best advice is to keep a careful watch on the skies from midnight until dawn on November 18. One thing is for certain: If you are not watching, then you'll miss it.

### Galilean Satellites

Following the elaborate dance of Jupiter's four Galilean moons can be exciting. Eclipses and transits or occultations are a common occurence with these jovian satellites. Use the accompanying chart to plan a night of observing and tracking their motions.

### Jovian Moon Events for November 2001

**Nov. 1**
5:29 I.Sh.I.
5:38 II.Ec.D.
6:28 III.Ec.D.
6:40 I.Tr.I.
7:42 I.Sh.E.
**Nov. 2**
2:43 I.Ec.D.
6:10 I.Oc.R.
23:57 I.Sh.I.
**Nov. 3**
0:18 II.Sh.I.
1:07 I.Tr.I.
2:11 I.Sh.E.
2:43 II.Tr.I.
3:06 II.Sh.E.
3:22 I.Tr.E.
5:31 II.Tr.E.
21:11 I.Ec.D.
**Nov. 4**
00:38 I.Oc.R.
20:28 III.Sh.I.
20:39 I.Sh.E.
21:49 I.Tr.E.
23:22 III.Sh.E.
23:58 II.Oc.R.
**Nov. 5**
1:06 III.Tr.I.
4:07 III.Tr.E.
23:07 IV.Sh.I.
**Nov. 8**
0:58 IV.Sh.E.
7:22 I.Sh.I.
8:12 II.Ec.D.
8:28 I.Tr.I.
**Nov. 9**
4:37 I.Ec.D.
7:59 I.Oc.R.
**Nov. 10**
1:50 I.Sh.I.
2:55 I.Tr.I.
2:55 II.Sh.I.
4:04 I.Sh.E.
5:09 II.Tr.I.
5:10 I.Tr.E.
5:42 II.Sh.E.
7:58 II.Tr.E.
23:05 I.Ec.D.
**Nov. 11**
2:27 I.Oc.R.
20:19 I.Sh.I.
21:22 I.Tr.I.
21:29 II.Ec.D.
22:33 I.Sh.E.
23:37 I.Tr.E.
**Nov. 12**
0:26 III.Sh.I.
2:22 II.Oc.R.
3:22 III.Sh.E.
4:43 III.Tr.I.
7:44 III.Tr.E.
20:54 I.Oc.R.
**Nov. 13**
19:00 II.Sh.E.
21:09 II.Tr.E.
21:34 III.Oc.R.
**Nov. 16**
6:14 IV.Ec.D.
6:31 I.Ec.D.
**Nov. 17**
3:44 I.Sh.I.
4:43 I.Tr.I.
5:31 II.Sh.I.
5:58 I.Sh.E.
6:57 I.Tr.E.
7:33 II.Tr.I.
**Nov. 18**
0:59 I.Ec.D.
4:14 I.Oc.R.
22:12 I.Sh.I.
23:09 I.Tr.I.
**Nov. 19**
0:02 II.Ec.D.
0:26 I.Sh.E.
1:24 I.Tr.E.
4:26 III.Sh.I.
4:43 II.Oc.R.
7:22 III.Sh.E.
8:16 III.Tr.I.
19:28 I.Ec.D.
22:41 I.Oc.R.
**Nov. 20**
18:49 II.Sh.I.
18:54 I.Sh.E.
19:51 I.Tr.E.
20:44 II.Tr.I.
21:37 II.Sh.E.
23:32 II.Tr.E.
**Nov. 22**
21:21 III.Ec.R.
22:01 III.Oc.D.
**Nov. 23**
1:04 III.Oc.R.
8:25 I.Ec.D.

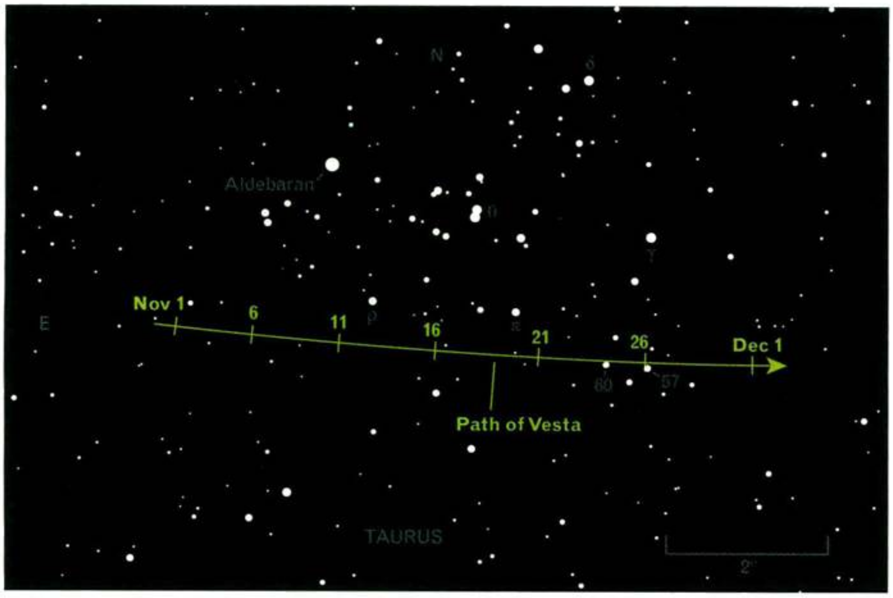


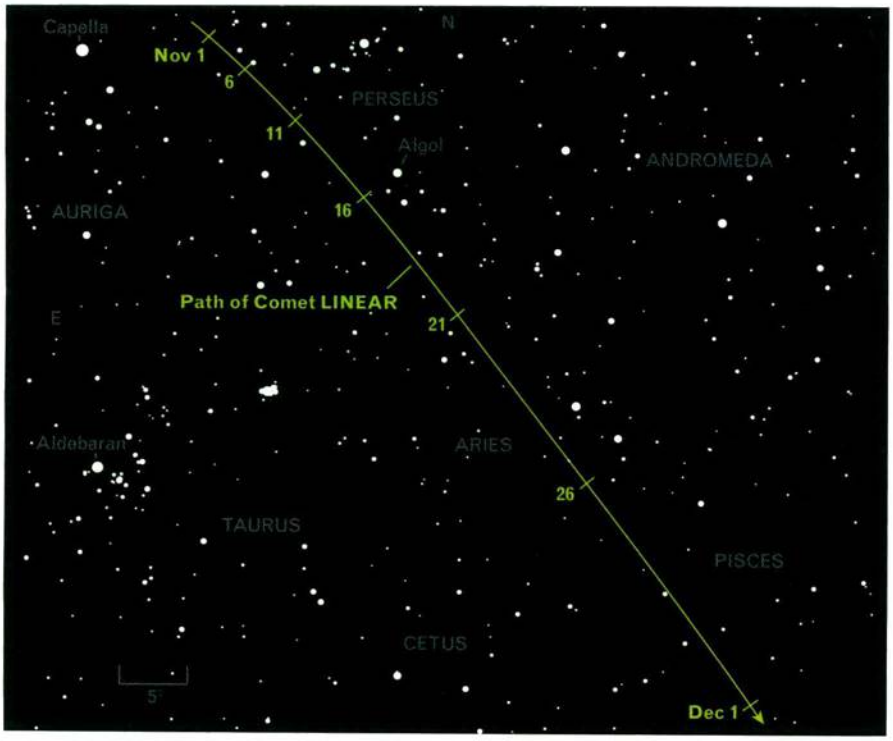
Looking east
3 A.M., November 18

### LINEAR Brightens for Binoculars

Following on the heels of summer's naked-eye Comet LINEAR A2, another dirty snowball holds lots of promise. Discovered by the same robotic telescope (at Lincoln Near Earth Asteroid Research), Comet LINEAR WM1 moves slowly across our evening skies in the east.

All comets are best visible under dark skies because their tails and comae, the outer fuzzy shroud of gas and dust, can easily get lost in the skyglow from city lights or a bright moon. Wait until the second week of November for a nice early evening view before moonrise. At midmonth the comet will be highest in the moon-free sky around midnight. The crescent moon returns to the evening sky during the third week, so wait until midnight for a better look.





Through binoculars, Comet LINEAR WM1 should appear fairly round, with a noticeably brighter center. In a telescope, you may be able to spot a stubby tail pointing northeastward. Early in November the tail will hide behind the comet. By next month we'll be seeing it almost broadside.

Starting in the rich starfields of Perseus, LINEAR WM1 should look like the globular cluster M15 in Pegasus, but a bit fainter, at about 8th magnitude. When it crosses into the sparser fields of Aries and Pisces, the comet should approach naked-eye visibility.

### Asteroid Vesta through Binoculars

This year, Taurus the Bull sports two eyes, thanks to Saturn floating close to Aldebaran. All month long, the second largest asteroid, Vesta, cruises through the binocular field of Aldebaran and the Hyades star cluster. If you can steady your binoculars and use the chart to look in the right place, Vesta should be visible from most suburban backyards.

At 310 miles (500 km) in diameter, Vesta shines at 7th magnitude, brighter than the numerous faint stars of the Taurus Milky Way. Curiously, it has a reflectivity, or albedo, of 0.38, which is among the highest of the asteroid family. The moon, in comparison, has an albedo of only 0.05, reflecting just five percent of incoming sunlight.

Discovered almost 200 years ago by Heinrich Olbers, on March 29, 1807, Vesta is named for Zeus' sister, Goddess of the Hearth.

During the last week of November, Vesta slides through a quadrangle of 6th- to 7th-magnitude stars including 57 and 60 Tauri. Challenge yourself and see if you can follow it from one night to the next without a chart. **A**

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*Martin Ratcliffe is Director of Theaters at the Exploration Place in Wichita, Kansas. Alister Ling is a meteorologist working for Environment Canada in Alberta.*

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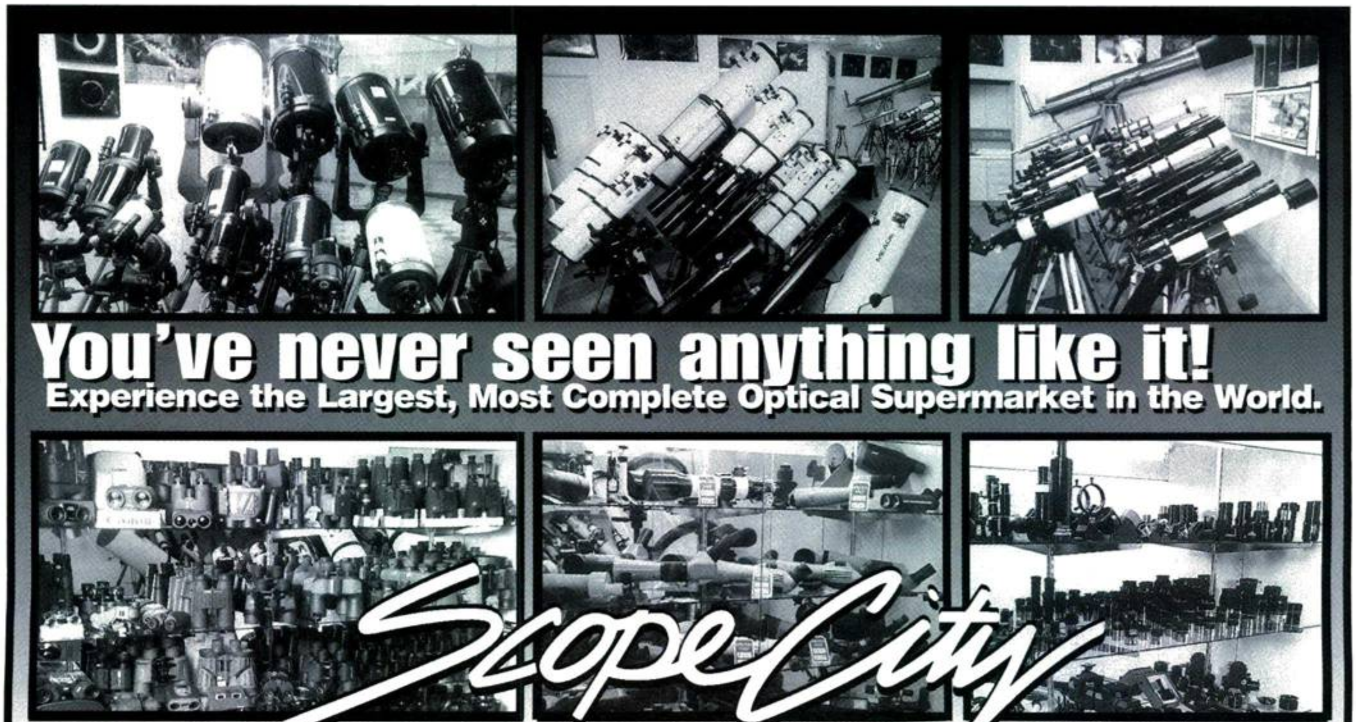
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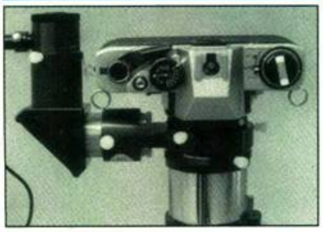

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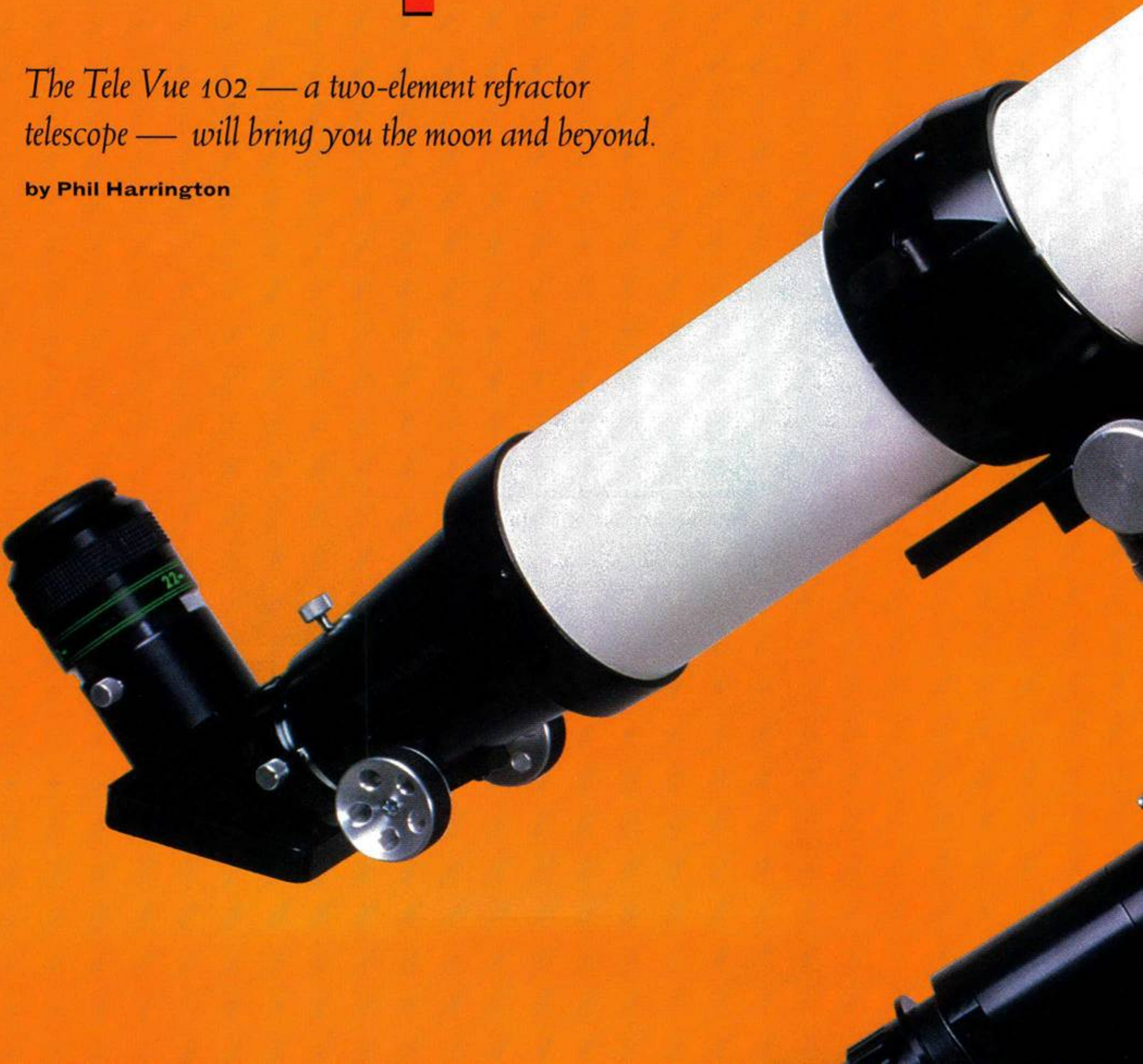
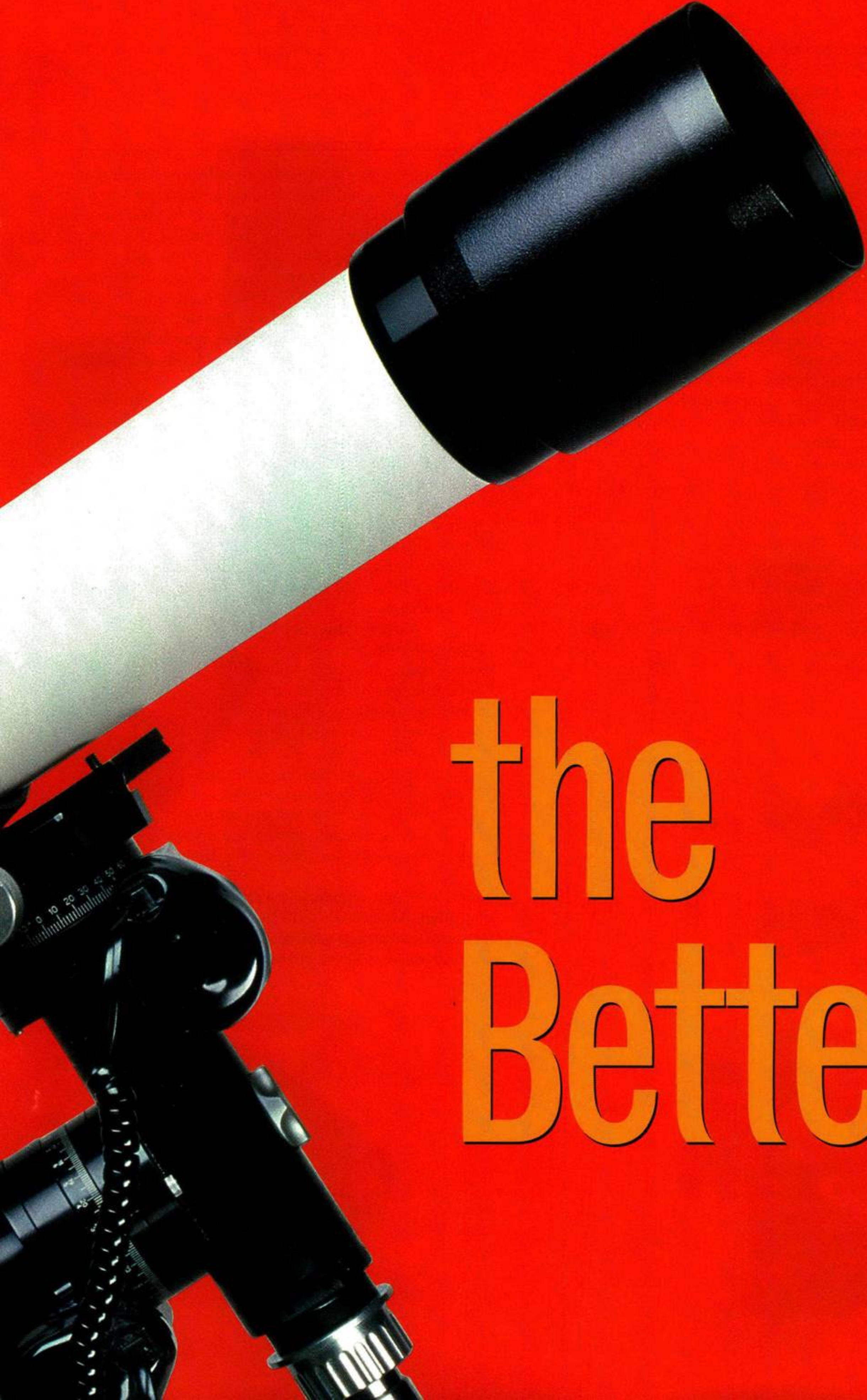
# the Simpler...

*The Tele Vue 102 — a two-element refractor telescope — will bring you the moon and beyond.*

**by Phil Harrington**





# the Better

**IT IS OFTEN SAID THAT SIMPLICITY BREEDS PURITY.** When considering telescopes, this axiom holds true, especially with the Tele Vue 102 and its imaging capabilities.

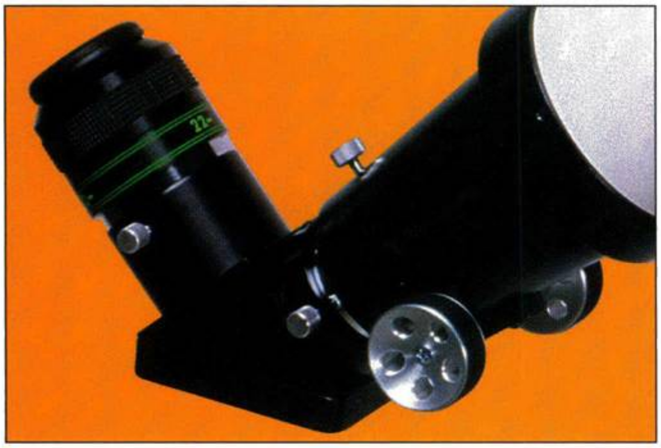
Ever since company founder Al Nagler introduced his line of Plössl eyepieces in 1979, Tele Vue has set the standard in quality optical products for amateur astronomers. In 1982, Nagler decided to enter the high-end refractor market with his MPT (Multi-Purpose Telescope). This was followed by a number of different instruments, including the Renaissance, Genesis, Pronto, Ranger, Tele Vue 85, Tele Vue 101, and the limited edition Tele Vue 140.

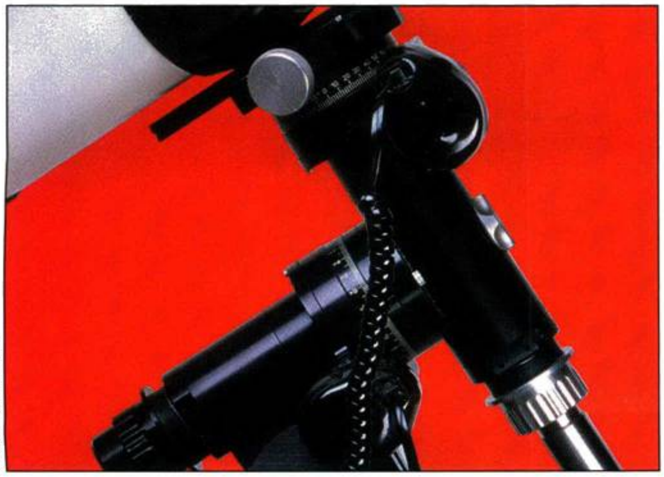
Most recently, Tele Vue introduced a refractor called the Tele Vue 102 (TV102). The heart of this telescope beats around a 4-inch f/8.6 objective lens. Unlike the TV101, which focuses starlight into the eyepiece using a complex of four separate lens elements set in two groups, the TV102 has a simpler two-element design.

The optical interplay of these elements produces tack-sharp images of the moon, planets, stars, and brighter deep-sky objects, which are nearly devoid of the false color (called secondary spectrum) that plagues many achromatic refractors.

I have been fortunate enough to use several TV102s since the telescope was first introduced in 2000, and all have performed flawlessly.

As is custom with every telescope I evaluate, I began by performing the "star test" — the tell-all check that compares the appearance of a star slightly inside of focus versus slightly outside of focus. Each TV102 displayed a perfect set of diffraction rings on either side of focus, just as a high-quality telescope should. And for those who are interested, I would estimate the final wavefront at the eyepiece to be no less than ⅛ wave, or even better. If you're not familiar with such optical jargon, then this is just another way of saying the optics in the TV102 are among the finest in this telescope's size and class.





Astronomy: Jim Forbes

**LET'S PUT SOME OF THIS PERFECTION** into practice. When viewing the moon through an achromatic telescope, the lunar limb is usually accentuated by tinges of blue, purple, or yellow, depending on how you hold your head to the eyepiece. These telescopes also show similar false colors, or secondary spectrum, around brighter stars and planets (unless the telescopes' focal ratios are quite high, greater than about f/13 for a 4-inch scope). However, an apochromatic refractor should eliminate secondary spectrum entirely. Even at high power, the TV102 gave only the slightest hint of secondary spectrum around Vega, and absolutely none when viewing the moon.

Speaking of the moon, I could spend hours exploring the countless nooks and crannies on the lunar surface visible through the TV102. And while the level of detail was exquisite, what really impressed me was the lunar starkness. Unlike some traditional achromatic refractors, which seem to cover the moon with a haze due to scattered light within the instruments' optical systems, the TV102 displayed detail with amazing definition. The shadows that covered the crater floors near the lunar terminator were pitch black, rather than a milky gray, while crater rims, rilles, and mountain ranges all showed a crispness.

Turning to more traditional deep-sky objects, my first target was Epsilon Lyrae, the famous Double-Double star. With a 9mm eyepiece (97x) in place, all four components were easily and cleanly resolved. Next stop was M13, the Hercules Cluster. Using a 12mm Tele Vue Nagler eyepiece (73x), the cluster dissolved into countless stars, with many strung together in arcing threads, giving the appearance of legs reaching out from a giant celestial spider. Several other

**Left: The two-inch focuser glides in and out with just the right amount of effort. Bottom left: The TV102 can be mated to any tripod with a standard ¼-20 photographic mount. Bottom right: The tube is topped off with a high-quality 4-inch objective lens.**

## Tele Vue 102

**Specs:** 4-inch f/8.6 doublet refractor

**Suggested Retail Price: $2150**
(Complete package with Everbrite diagonal, 2" to 1.25" adapter, 20mm Plössl eyepiece, and ring mount, goes for $2550)

**Comes with:**
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globular clusters, including M2, M10, M12, and M92, were also well defined with the TV102.

**PERHAPS MY FAVORITE VIEWS CAME** when I paired the TV102 with my 22mm Tele Vue Panoptic eyepiece. This combination yielded a magnification of 40x and an impressive 1.7° field of view. Favorites such as the Lagoon Nebula (M8) and the Double Cluster (NGC 869 and NGC 884) quickly became sparkling gems against their brilliant, star-filled backdrops. Incidentally, a 55mm Plössl will produce the TV102's largest field of view: three degrees.

Light throughput is excellent with the TV102, as evidenced by glimpses of stars up to 13th magnitude — not bad for a "small" telescope. Image contrast is also superlative with the TV102, with fine details in the many belts of Jupiter showing through clearly. The more subtle features of Saturn's atmosphere were also evident, as was Cassini's Division in the planet's rings. The Crepe, or C ring of Saturn was also apparent, silhouetted against the bright, yellowish planetary disk.

Photographically, the TV102 should be a winner, although I did not test it in this capacity. Tele Vue cautions that a field flattener is needed for distortion-free photography of star fields. A dedicated 0.8x reducer/flattener is available that reduces the TV102's focal ratio to f/6.9, while also producing pinpoint star images from edge to edge.

The TV102 performs just as well mechanically as optically. Although the tube assembly weighs only 10 pounds and measures 31 inches from tip to tip, it feels quite sturdy. The 2" focuser, made from machined aluminum with internal Teflon pads, glides in and out with just the right amount of effort (although it can be adjusted, if desired) and shows no evidence of wobble or backlash.

**UNLIKE OTHER TELE VUE TELESCOPES,** the TV102 is sold without an eyepiece, star diagonal, or tripod-mounting ring. If you are a first-time refractor buyer, then you also have to select and purchase those items, as well as a suitable mounting. Although this may seem like a drawback, it actually allows the purchaser to customize his or her accessories to suit individual needs. Unless you already own one, you will need to buy a 2" star diagonal, such as Tele Vue's own Everbrite diagonal; several other manufacturers also offer suitable units, which typically range in price from $100 to $255. Unless you plan on using only 2" eyepieces, be sure to get a 1.25" adapter, if one is not supplied with the diagonal.

A finder may also be on your shopping list. Select from a one-power "unity" finder, such as Tele Vue's Starbeam or Quik-Point, or a magnifying finderscope — all priced between $25 and $180.

Finally, you may need Tele Vue's ring mount (Item # RM4-0001, $120), which mates the TV102 to any tripod with a standard ¼-20 photographic mount. The Tele Vue Gibraltar altazimuth mount is ideal for the TV102, as are the Vixen Great Polaris or GP-DX, Celestron CG-5, and Losmandy GM-8 equatorial mounts.

The Tele Vue 102 has quickly established itself as one of the finest refractors in its size class sold today.

---

*Phil Harrington's equipment reviews appear often in* Astronomy. *His book* Star Ware *is available through bookstores as well as his website: http//www.philharrington.net.*

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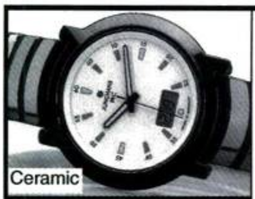

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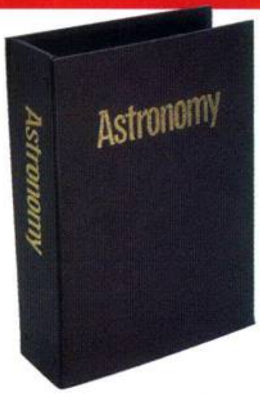

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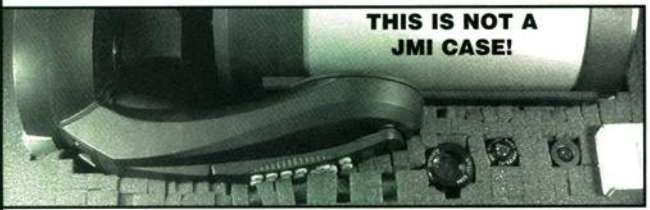

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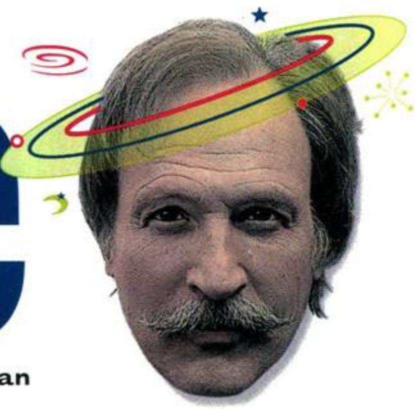
# strange Universe



by Bob Berman

## Eat the Aliens

Clearly, many of us are excited about the possibility of finding extraterrestrials. Thousands of people have even donated their idle computers to help SETI analyze data. We assume life is plentiful elsewhere, but acknowledge the remote possibility that we're the whole show.

Science is supposed to be dispassionate, but philosophy still manages to creep into our endeavors. The notion that the universe's inventory of 125 billion galaxies is just an immense, dumb, inanimate backdrop for a single large-brained species, whose leisure-time activities include bingo and stock-car racing, is too bizarre to be plausible.

So we search. Finding any sort of life would provide a hundred conclusions to fill the vacuum of today's guesses, and elevate exobiology to a science whose subject is real rather than imaginary. Lacking hard data, we meanwhile occupy our time with assumptions.

Much of our collective mindset comes from science fiction novels and movies, which present aliens as either benign and cuddly (like ET) or obsessed with destroying us. Sometimes they're slimy squid-like things that take over the bodies of everyone in the neighborhood, a process that understandably changes people's personalities, usually by making them as emotionless as Al Gore. It's an odd thing to do. If we discovered squid on some other world, would our first impulse be, "Now let's crawl into these disgusting things and see if we can become squid ourselves?"

Sometimes, though, the aliens are benign and their desire to obliterate humans stems from some larger benevolent motive (e.g. to help stop our own destructive activities like rainforest defoliation and futile chronic dieting). Or else they're really benign and come bearing unspecified wisdom or to welcome us into some sort of Interplanetary League of Nice Protoplasm.

So movies see aliens as either good or bad: they either love us or hate us. But actual aliens might be neither; they could arrive out of simple curiosity. They'd look around without bothering to say a word and then go their merry way. We'd be left thinking, What was that about?

They might come to proselytize, as interstellar Hare Krishnas or Jehovah's Witnesses. They fly in, distribute a few billion leaflets about a cause we don't understand, and then attempt to recruit followers. It's been said that technology just 100 years ahead of ours would be indistinguishable from magic. If aliens could hover without visible support, or light cigarettes by staring at them — that would hold our attention long enough for them to sermonize. You know some people would join their religion no matter how bizarre it is.

Then again, aliens might have incomprehensible motives, or likes and dislikes incompatible with our own. Just as dolphins are intelligent but have entirely different pastimes from us, aliens might be into stuff we'd find excruciatingly boring. They'd invite us to push pebbles around with our noses while they giggled hysterically. We'd soon grow bored, see the whole invasion as pointless, and start ignoring them like an interminably bad novel with no purpose or punch line.

The worst thing would be if we found them irresistibly appetizing — or vice versa. If aliens tasted like a shrimp cocktail, project SETI might evolve into a fast-food enterprise: a Search for Extra Tasty Individuals. Any aliens studying us right now would have reason to worry. We eliminate rainforest species faster than we catalog them, all to graze cattle for hamburgers. Lunch first, science later.

Then too, the aliens may simply be jokesters. Even babies smile — maybe humor is universal. The space creatures come here in search of new laughs, bringing flying saucers full of whoopee cushions and chattering teeth, novelty gags with universal appeal. They cruise the galaxy to boldly joke where no one has joked before. Suddenly all of Earth's televisions magically turn on and there's an alien on the screen saying "Greetings from Earth — oh, wait, we're not from Earth, you are. Heh heh. But seriously folks . . . "

Maybe they simply want to talk. Perhaps aliens would pay us a visit just to have an ordinary conversation. "Hey, what's happening?" would be their opening words.

You can picture our solemn spokeshuman standing awkwardly in front of the giant saucer on the White House lawn, carefully replying, "Greetings from the citizens of Earth."

"Yeah, so what's up, bro?" the alien says.

"Well, er, er, nothing much."

"Nothing much? Come on! We've monitored your cell phone transmissions; you've got a billion conversations going on all the time. We've traveled for 1.8 megafreons to find out what all that gab is about. Whaddya mean, nothing much? "

It soon becomes clear they won't shut up. They've obviously been drinking tons of coffee to stay awake during the long haul from Tau Ceti and we can't keep up with them. As with any conversation, the small talk starts growing stale, the news gets old, and the aliens depart for better gossip.

With all these possible alien motives, movie directors should be able to come up with something besides attack or befriend.

One familiar sci-fi concept is that our ancestors were rocketed here by a distant dying planet, or as part of a galaxy-wide seeding project. Now aliens arrive merely to check up on our progress to see if we've evolved enough to join their planetary community. (After a quick visit to our malls, they decide to put the invitation on hold for another billion years).

A variation of this theme has NASA's future astronauts discovering human ancestors on Mars or Ganymede. We tiptoe into a strange, enormous structure, and there's someone who looks like Trent Lott or Al Sharpton saying, "I've been expecting you." Eventually the screams fade away and we get used to it.

As to the intelligence of the creatures we stumble upon, both films and science come up with limited choices. The aliens are either way ahead of us, or they're moss. Rarely are they something in between, such as large personable frogs that have acquired a taste for space travel as they go about in their search of bigger ponds.

Speaking of which, what really sets Earth apart is its copious water. We might well attract water-loving creatures whose reasons for coming have nothing to do with us at all. They see our continents as just irrelevant stuff between oceans, and view our world as a vast underdeveloped aquatic park.

And would we even see them? If they moved a thousand times faster than flitting flies, there might not be a trace of them. Maybe they'd be chameleons, or energy-aliens, or made of dark matter, or move at such a slow rate we'd overlook them, shrugging them off as inanimate structures. Should an encounter occur, it would probably be something we couldn't have imagined in our wildest dreams.

We're sure of just one thing: There's life on Earth. Too much extrapolating from any sole data-point almost certainly heads off in a wrong direction. So we'll keep watching the sky and helping SETI when we can. But let's stay wide open: If an encounter happens, not even the sky will be the limit. ◼

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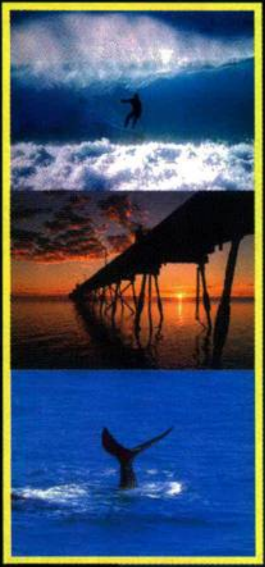

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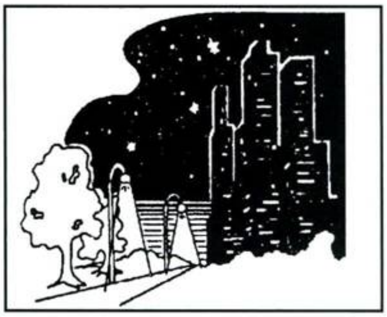

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▶ It really works! This miniature refractor telescope with three interchangeable eyepieces is the perfect office gift or collectable for any die-hard astronomy buff. The brass Greenwich-2000, by Solus of Japan, displays superb detail — down to its rack-and-pinion focusing. The star diagonal accommodates eyepieces of 10x, 15x and 20x magnification. This little scope stands roughly one foot high and boasts an optical tube length of approximately nine inches.

The Greenwich-2000 comes ready for assembly in a brilliant red "presentation box" that's sure to impress. Screw in the tripod legs, and aim the alt-azimuth mount out your office window. Priced at about $135 (plus shipping), it's a compact, elegant toy scope that's sure to be a hit with the person who already has everything.

*Contact The Widescreen Centre, 48 Dorset Street, London, England, W1U 7NE; telephone, (020) 7935 2580; fax: (020) 7486 1272; e-mail, tony@widescreen-centre.co.uk; website, http://www.widescreen-centre.co.uk.*

Greenwich 2000 by Solus

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### Peterson Engineering Corporation Offers Products to Ease Viewing

▶ Peterson Engineering Corporation, of Barrington, Rhode Island, offers two new products to assist your observing sessions: the Mounting Assistant and the EZ Focus Kit.

The Mounting Assistant plate ($77.85 plus shipping and handling) attaches to Meade's standard field tripod. It simplifies the attachment of a Meade SCT or MCT for use in the alt-azimuth mode. This handy plate fits the 7-inch MCT as well as the 8-inch, 10-inch, and 12-inch SCTs.

Made from ¼-inch-thick alloy 6061T6 aircraft aluminum, the Mounting Assistant is finished with black anodize for a refined look. The vinyl-covered steel mounting guide posts prevent marring the telescope base. Milled slots on both sides provide a convenient hanging point for the keypad hand controller.

Thanks to the plate's thickness, the telescope sits firmly aligned upon the plate and its mounting screw. The rounded end of the telescope base rests against three yellow positioning fingers. The Mounting Assistant allows easy access to the eyepiece, even when viewing directly at the zenith. Best of all, the Mounting Assistant's compact size permits convenient storage in limited space without disassembly.

Peterson's EZ Focus Kit ($30; s/h included for U.S., Canada, and Mexico) is intended for use with Meade 7-inch or larger Schmidt-Cassegrain and Maksutov-Cassegrain telescopes. It not only removes most of the backlash from the focusing system, but also consistently provides a precise feel to the focuser knob.

The EZ Focus Kit modifies the Meade focus system by substituting precision thrust bearings for nylon washers, reducing the need for separate backplate-mounted focusers and motorized focus controls. The instruction sheet contains detailed step-by-step instructions and illustrations. The only tool you'll need is pliers.

The kit also contains two precision miniature thrust bearings, a custom stamped stainless steel thrust washer, an Allen wrench, a mirror cell retaining bolt, and a packet of lubricating grease favored by Meade.

*Order either of the two accessories directly from Peterson Engineering Corporation, 405 New Meadow Road, Barrington, Rhode Island 02806; phone/fax: (888) 712-9332; outside U.S.: (401) 245-6679; e-mail, pecorp@fastdial.net; website, www.peterson-web.com.*

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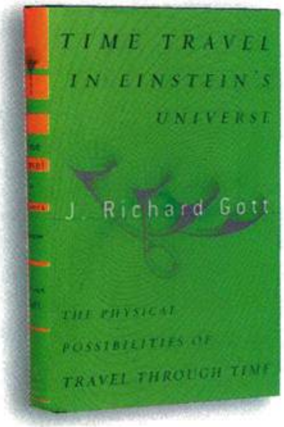

TIME TRAVEL IN EINSTEIN'S UNIVERSE
J. Richard Gott
THE PHYSICAL POSSIBILITIES OF TRAVEL THROUGH TIME

### Time Travel in Einstein's Universe: The Physical Possibilities of Travel Through Time

J. Richard Gott, 291 pages, Houghton Mifflin Company, Boston, 2001; ISBN 0-395-95563-7; hardcover, $25.

▶ J. Richard Gott's book, *Time Travel in Einstein's Universe,* is an entertaining and lucid account of the possibilities of time travel in the context of relativity. The book begins with an interesting discussion of why one would dream about time travel. The necessary conundrums including the time paradox of killing your ancestors before your direct line comes into being are brought out to illustrate the necessity for self-consistency.

Indeed, the theme of self-consistency — a major strength of Gott's research — is reflected throughout the book. This self-consistency is particularly important for time travel, for not only must the equations be satisfied exactly, but they must also satisfy the idea of causality and the illusion/issue of free will.

As a precursor to a later chapter, Gott tells a wonderful story of a person who, through time travel, manages to meet his own mother and father. This makes the introduction of the time Jinn (like magic Jinni) perfectly normal and logical as a necessary tool of time travel.

The first part of the book is full of wonderful and provoking ideas that set up the succeeding discussions of time travel to the future — for example, Gott discusses how a cosmonaut has already done this on a limited scale — and then time travel to the past. The latter is the portion that makes the conundrums so real to us because it affects our here and now rather than some "distant future."

It is also clear that it will take a very special machine — made from material that we have not yet found in the universe but of which we have only seen hints or theoretical possibilities — to time travel to the past. This discovery could lead to warp drive or travel faster than light.

I found chapter four particularly fascinating, because in it Gott discusses the relationship of time travel to the beginning of the universe. At his urging, graduate student Li-Xin Li figured out a self-consistent solution to Einstein's general relativity equations that shows that the universe could be its own progenitor. This solution is echoed in the artist's conception on the cover of the book, which looks like a hydra cornucopia. In another chapter, entitled "Report from the Future," Gott goes out on a limb when he predicts the span of human existence based upon a technique he has developed.

Overall, *Time Travel in Einstein's Universe* provides a clear exposition of the relativity and related principles for time travel, as well as an autobiographical insight into an active researcher and his colleagues. — *Experimental astrophysicist George Smoot is an active researcher in observational astrophysics and cosmology at the Lawrence Berkeley National Laboratory and the University of California at Berkeley*

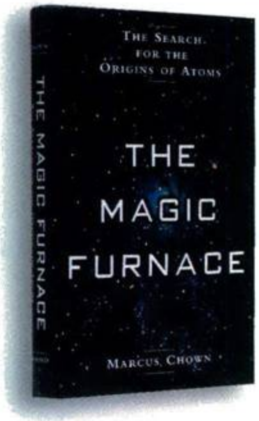
### The Magic Furnace: The Search for the Origin of Atoms

Marcus Chown, 232 pages, Oxford University Press, New York, 2001: ISBN 0-19-514305-1; hardcover, $25.

▶ Suspense is the mark of a good storyteller, and *The Magic Furnace: The Search for the Origin of Atoms* keeps readers anxious for the next puzzle piece to fall into place. Marcus Chown, a cosmology consultant for London's *New Scientist* magazine, tells the story behind the researchers who eventually discovered the elusive source of solar energy. And he does it with an entertaining writing style borrowed from fellow Londoner Arthur Conan Doyle, for *The Magic Furnace* reads like a Sherlock Holmes novel.

Chown weaves an intricate story that ultimately solves a much larger mystery: Where did the sun originate and how did it all begin? He explores the irony of carbon-based life forms obtaining the necessary ingredients to eventually gaze skyward and ponder their own existence. He finds the answer in the magic furnace — the birthplace of creation.

In *The Magic Furnace,* Chown creates a vivid mental picture of the arcane world of nuclear physics: "Every breath you take contains atoms forged in the blistering furnaces deep inside stars. Every flower you pick contains atoms blasted into space by stellar explosions that blazed brighter than a billion suns. Every book you read contains atoms blown across unimaginable gulfs of space and time by the wind between the stars."



Chown devotes the first two-thirds of his book to a lengthy chain of scientific discoveries that led to unlocking the very nature of matter, such as how the iron got there in the first place. He details ancient theories that led to other discoveries. For example, around 470 B.C., another Greek philosopher, Democritus, pondered this problem: If you keep dividing an object in half, eventually you'll reach a point where no further division is possible. The result, Democritus reasoned, must be an atom, because the Greek word for "uncuttable" was "a-tomos."

From there, Chown leads us on a fascinating trip through the centuries as a cast of philosophers and scientists strives to understand the world around

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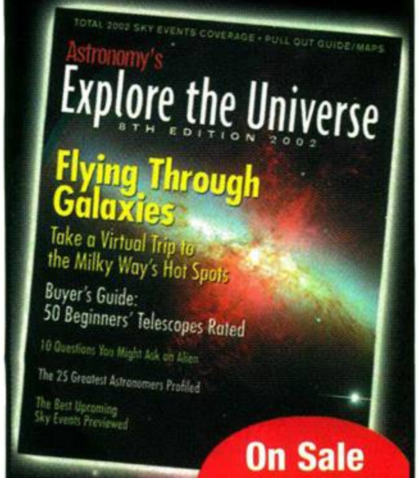
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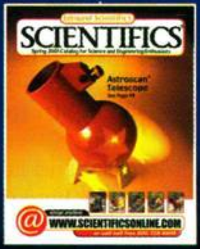

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them. We're introduced to the characters whose names are now enshrined as units of measurement or attached to instruments: Lord William Kelvin, Hans Geiger, Marie Curie, Wilhelm Roentgen, Henri Becquerel. With each goes a personalized story that brings the individual to life.

In 1808, Josef von Fraunhofer, a poor apprentice in a Munich, Germany, optical shop, was polishing a lens when the roof of his workshop collapsed on him. Reward money and a promotion from a grateful employer gave Fraunhofer the freedom to experiment with optics. Six years later, he began examining sunlight with a device called a spectroscope. This technique, called spectral analysis, eventually led to the identification of atomic elements in light streaming from the sun and the stars. To everyone's surprise, the sun, stars and Earth were all made from the same kind of stuff.

The last third of the book deals with the classic "chicken or egg" question. Were the elements created 14 billion years ago immediately after the Big Bang, or were they created later in the solar furnaces of exploding supernovae? Both, says Chown. The lightest elements, hydrogen and helium, originated in the Big Bang, only to be transmuted later into most of the heavier elements during the death gasps of expiring stars.

Near the end, *The Magic Furnace* bogs down with some tedious details of nuclear physics. Some readers may gloss over this section.

But like any good mystery, Chown's last paragraph raises a huge philosophical question — in this case, how atoms (meaning humans) developed the ability to be curious about themselves. — *Nick Nichols is the former media relations manager for the Idaho National Engineering and Environmental Laboratory in Idaho Falls, Idaho*

### Parallax: The Race to Measure The Cosmos

Alan W. Hirshfeld, 198 pages, W. H. Freeman and Company, New York, 2001; ISBN 0-7167-3711-6; paperback, $23.95.

Measuring the distance of a star from Earth is fairly routine these days. Astronomers call up satellites, position inner-space telescopes, and tap out orders from their laptop computers. As a result, we learn about the movement of stars within our galaxy, the age and composition of distant star clusters, the size of nearby giant stars — and, ultimately, our place in the universe.

Parallax
The Race to Measure the Cosmos
Alan W. Hirshfeld
Parallax

But like all modern scientific endeavors, the ability to "see" the night sky in 3-D wasn't always this easy. Instead, it's the result of knowledge and instruments developed by countless bright minds over thousands of years. To pay homage to these accomplishments, astronomer Alan Hirshfeld took a year-long sabbatical from the University of Massachusetts at Dartmouth to contemplate the "hunt" among astronomers for parallax — the phenomenon by which we now measure stellar distance. The result: a book by the same name, which not only details the history of observational astronomy, but also reveals science as a human endeavor.

The book begins in ancient Alexandria, in 270 B.C., with Greek philosopher Aristarchus of Samos. It travels through time with such well-known astronomers as Galileo, Newton, and Halley, all of whom tried but failed to prove parallax. And, it ends shortly after Friedrich Bessel becomes the first astronomer to measure stellar parallax, in Prussia in 1838, with a list of 20th-century achievements. But unlike textbooks, Hirshfeld's manuscript doesn't portray "a steady march forward to enlightenment." Instead, it diverges as the path itself did, showing historic figures as people, full of false hopes, fear of failure, jealousy, victory and joy.

We are introduced to Tycho Brahe, a hot-tempered Danish nobleman who lost part of his nose to a duel over mathematics; Caroline Herschel, a woman so dedicated to the advancement of astronomy that she placed morsels of food in her brother William's mouth as he polished mirrors for his telescopes; Josef von Fraunhofer, a poor boy who barely escaped a collapsed building to become a celebrated craftsman; and Reverend Fearon Fallows, a man who suffered horrendous conditions at his Snake Hill Observatory in Australia for early views of the southern sky.

Hirshfeld further personalizes this history with his own thoughts and reflections. He writes, for example, that "Stellar parallax beckoned astronomers the way an unconquered peak draws the mountaineer or a distant horizon calls the explorer," and that "Aristarchus stood as much chance of reversing the geocentric juggernaut as a mosquito turning back a freight train." Finally, he says, "Despite decades as an astronomer, I still find it hard to fathom that the Earth streaks through half a million miles of space while we snooze away the night in our beds."

Indeed, this comprehensive work, which quotes everyone from Mark Twain to Albert Einstein, and includes engravings of astronomers, diagrams of scientific concepts, and photos of early telescopes, will appeal to astronomy buffs and curious readers alike. For while at first the book is heavy with detailed scientific explanations and gedunken (thought) experiments, it lightens and brightens into an adventure story, leaving readers with the same satisfaction as a favorite college course by a gifted professor. — *Beth Livermore is a contributing editor for* Astronomy *magazine*

### Starry Night: Astronomers and Poets Read the Sky

David H. Levy, 203 pages, Prometheus Books, Amherst, New York, 2001; ISBN 1-57392-887-9; paperback, $18.

David Levy's small book, *Starry Night*, makes the perfect holiday gift for someone with an interest in both the night sky and poetry. And it's sure to expand some horizons for other readers.

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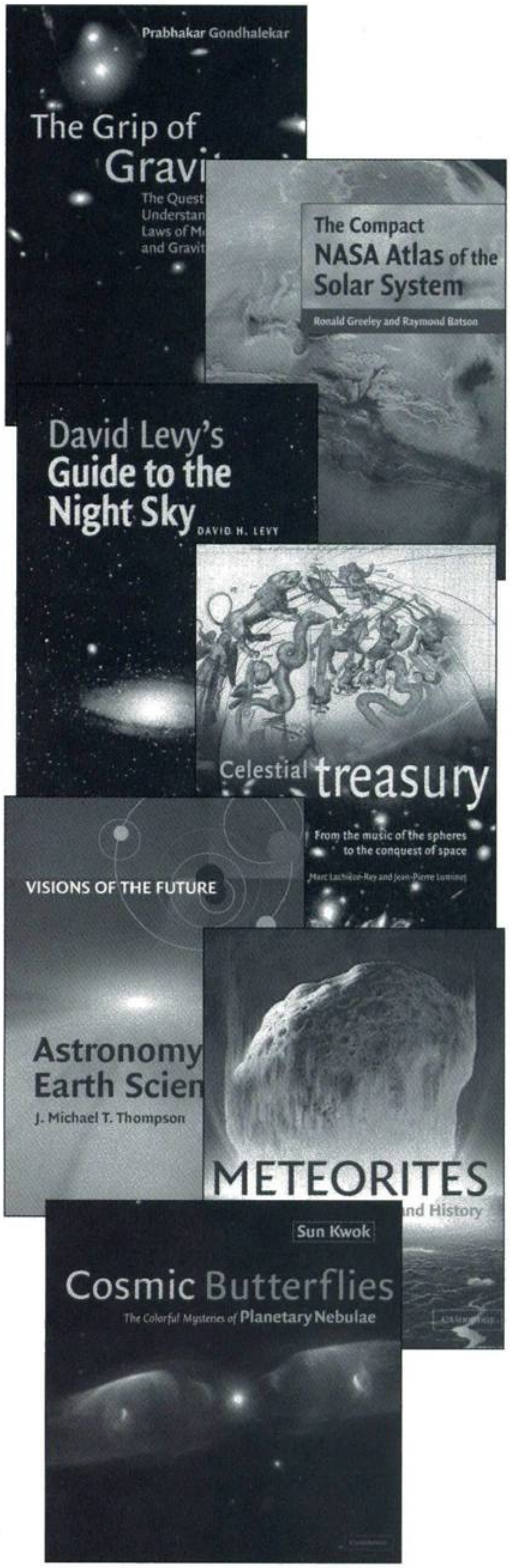
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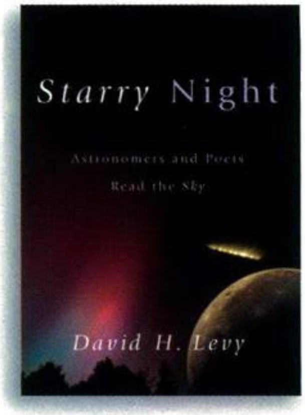


nomical discoveries through the poetry of the past 500 years, focusing most substantially on the poets of the Victorian Age.

The book emphasizes Levy's interest in comets. (Levy is the codiscoverer of comet Shoemaker-Levy 9, which made a famous assault on Jupiter right before Hubble's eye in 1994.) He pays close attention to 19th-century poet and comet-lover, Gerard Manley Hopkins — who is regarded as a precursor to modern poets and poetry.

Levy began *Starry Night* nearly 30 years ago in graduate school. His acknowledgments include a passage about an undergraduate Victorian poetry class at Acadia University, where his professor pointed out Tennyson's deep understanding of the science of his time.

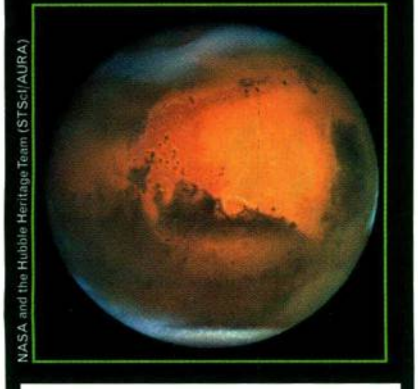
My biggest complaint with *Starry Night* is that it stops too early in the last millennium, virtually ignoring the elegant poetry of modern and contemporary periods — poetry written since the Big Bang became accepted science.

Perhaps next time, David. — *Bonnie Gordon,* Astronomy *editor*

## PRODUCT INFO

Suppliers send announcements and color photographs to Star Stuff, P.O. Box 1612, Waukesha, WI 53187, or e-mail starstuff@astronomy.com. *Astronomy* assumes no responsibility for the product information supplied by manufacturers. Prices are retail and subject to change without notice. Check *Astronomy*'s website for further product updates — http://www.astronomy.com

# NEXT month in Astronomy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## LOOKING AHEAD

NOVEMBER

Volunteers are the heart and soul of many organizations. This is no less true within the amateur astronomical community, where volunteers are instrumental in keeping the organizations running. Ultimately, the success of public events can be attributed to those who willingly donate their time and talents. Payoff comes in the form of "oohs" and "aahs" from first-time telescope viewers, the sparkle in the eyes of a child after a glimpse of the universe, the camaraderie of fellow club members, and satisfaction in a job well-done. This month, as we reflect upon the bounty within our lives, let's add thanks for the volunteers who have impacted our local organizations and consider becoming one of their ranks.

Jeffrey A. Gossman

**The photographer was tracking a satellite when this Leonid meteor took center stage.**

#### FIRST FRIDAY OF EACH MONTH

### Far Out Fridays

Adler Planetarium and Astronomy Museum, Chicago, Illinois. 5–10 P.M. For more information, contact (312) 922–STAR; TTY, (312) 322–0995; or view their website, http://www.adlerplanetarium.org.

#### OCTOBER 12–14

### South Jersey Star Party

Belleplain State Forest, Cape May County, New Jersey. Sponsored by the South Jersey Astronomy Club. Contact Paul Ostwald, 23 Isaacs Lane, Egg Harbor Township, NJ 08234; e-mail, paostwald@aol.com; website, http://members.aol.com/sjastroc.

#### OCTOBER 12–14

### Stella Della Valley

Camp Onas, Ottsville, Pennsylvania. Sponsored by the Bucks-Mont Astronomical Association. Contact Paul Kohler, (215) 453–0363; e-mail, ncc1701@vrinter.net, or Antoine Pharamond, (215) 412–9291; e-mail, apharamond@adelphia.net; website, http://bmaa.freeyellow.com.

#### OCTOBER 16–20

### Twin Lakes Star Party

Land Between the Lakes National Recreational Area, western Kentucky. Sponsored by the West Kentucky Amateur Astronomers. For more information, contact Ross Workman, (270) 797–8959; e-mail, planetman@vci.net; website, http://www.wkaa.net.

#### OCTOBER 17–21

### Deep South Regional Stargaze

Percy Quin State Park, near McComb, Mississippi. For more information, contact Barry Simon, 842 Crystal Street, New Orleans, LA 70124; (504) 283–7592; e-mail, bsimon615@aol.com.

#### OCTOBER 19–21

### Astronomy Camp for Adult Beginners

Mount Lemmon and Mount Bigelow Observatories, University of Arizona, Tucson, Arizona. Contact Don McCarthy, 933 North Cherry Ave., Tucson, AZ 85721-0065; (520) 621–4079; e-mail, dmccarthy@as.arizona.edu; website, http://ethel.as.arizona.edu/astrocamp.

#### OCTOBER 19–21

### Astronomy Jamboree

Custer Institute, Southold Town Recreation Center, and Orient Point State Park, Southold, New York. For more information, call (631) 765–2626, or view the website, www.custerobservatory.org.

#### OCTOBER 20

### Colorado Astronomy Day

Chamberlin Observatory, Observatory Park, University of Denver campus, Colorado. For more information, contact Steve Solon, (303) 932–7613; e-mail, galaxyshots@compuserve.com or Larry Brooks at (303) 986–5255; e-mail, LBrooks100@aol.com.

#### OCTOBER 26, NOVEMBER 17

### Shreveport Star Party

Ralph A. Worley Observatory, south of Shreveport, Louisiana. Contact Cran Lucas, (318) 797–1524; e-mail, clucas@softdisk.com; website, http://www.lsus.edu/nonprofit/sbas/.

#### OCTOBER 28

### Blue Ridge Parkway Regional Stargaze, Part II

Julian Price Park Picnic Area, Julian Price Park on the Blue Ridge Parkway, North Carolina. Contact Greg Kirby (828) 396–7656; e-mail, lmocvac@twave.net; website, http://users.twave.net/jafowiz/brprs.htm.

**NOVEMBER 3**

**Jersey Astro Conference and Showcase**

Union County College, Cranford, New Jersey. Sponsored by the Amateur Astronomers. Contact Linda Horning, (973) 693–5122; e-mail, jacs@asterism.org; website, www.asterism.org.

**NOVEMBER 3**

**The Violent Universe: Crashing Asteroids, Exploding Stars, and Cannibal Galaxies**

Dickson Art Center, University of California, Los Angeles, California. Lecture and multimedia program led by astronomer Andrew Fraknoi. 9 A.M.–5:30 P.M. Sponsored by the university and the Astronomical Society of the Pacific. For registration, telephone (310) 825–9971; for more information, contact (310) 825–7093; website, www.uclaextension.org.

**NOVEMBER 15–18**

**National Meeting of Brazilian Amateur Astronomers**

Salvador, Bahia, Brazil. Sponsored by the Associacao dos Astronomos Amadores da Bahia. Contact Wilton Carvalho; phone/fax, 55–71–367–0129; e-mail, wilton@e-net.com.br.

**NOVEMBER 17–18**

**Astrofestival**

Blindern, Oslo, Norway. Sponsored by the Norwegian Space Centre, the Research Council of Norway, and the University of Oslo, and organized by the Norwegian Astronomical Association and Teknoteket along with the National Science Center. Scandinavia's largest astronomical event will feature exhibitions, guest speakers, telescope stations, competitions, and hands-on activities for both children and adults. For more information, contact Knut Jorgen Roed Odegaard, Astrofestival 2001, P.O. Box 1029, Blindern, NO-0315 Oslo, Norway; telephone, 22–85–75–22; e-mail, knutjo@astro.uio.no; website, http://www.astro.uio.no/ita/arrangementer/astfest01/astfest01.html.

**CONTACT**

Please submit club announcements four months in advance to Looking Ahead, *Astronomy*, P.O. Box 1612, Waukesha, WI 53187, or to tconley@astronomy.com. Add your events to our online calendar at http://www.astronomy.com.

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Alaskan aurora photograph by Mike O'Leary

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Astronomy's

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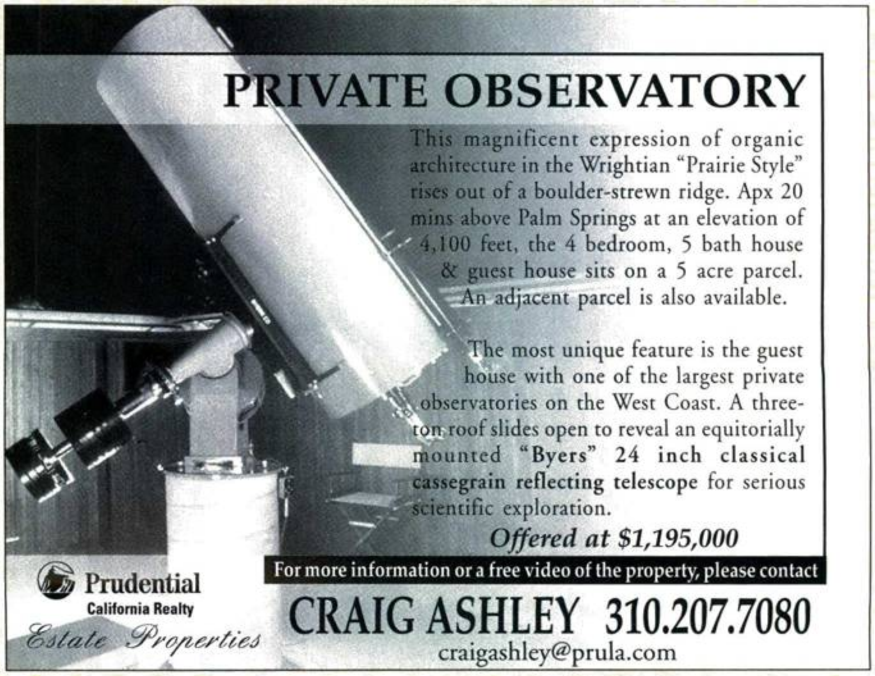

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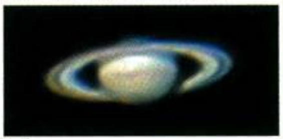

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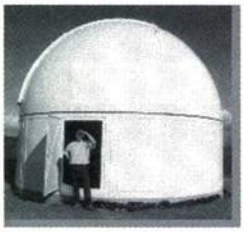

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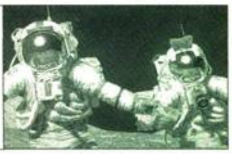

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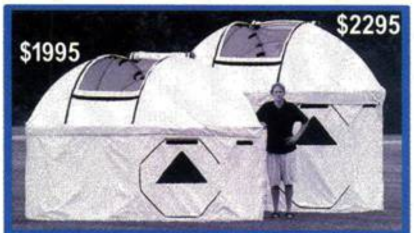

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## Stormy Weather Tests Patience

**Philippino students luck out when clouds part for a lunar eclipse.**

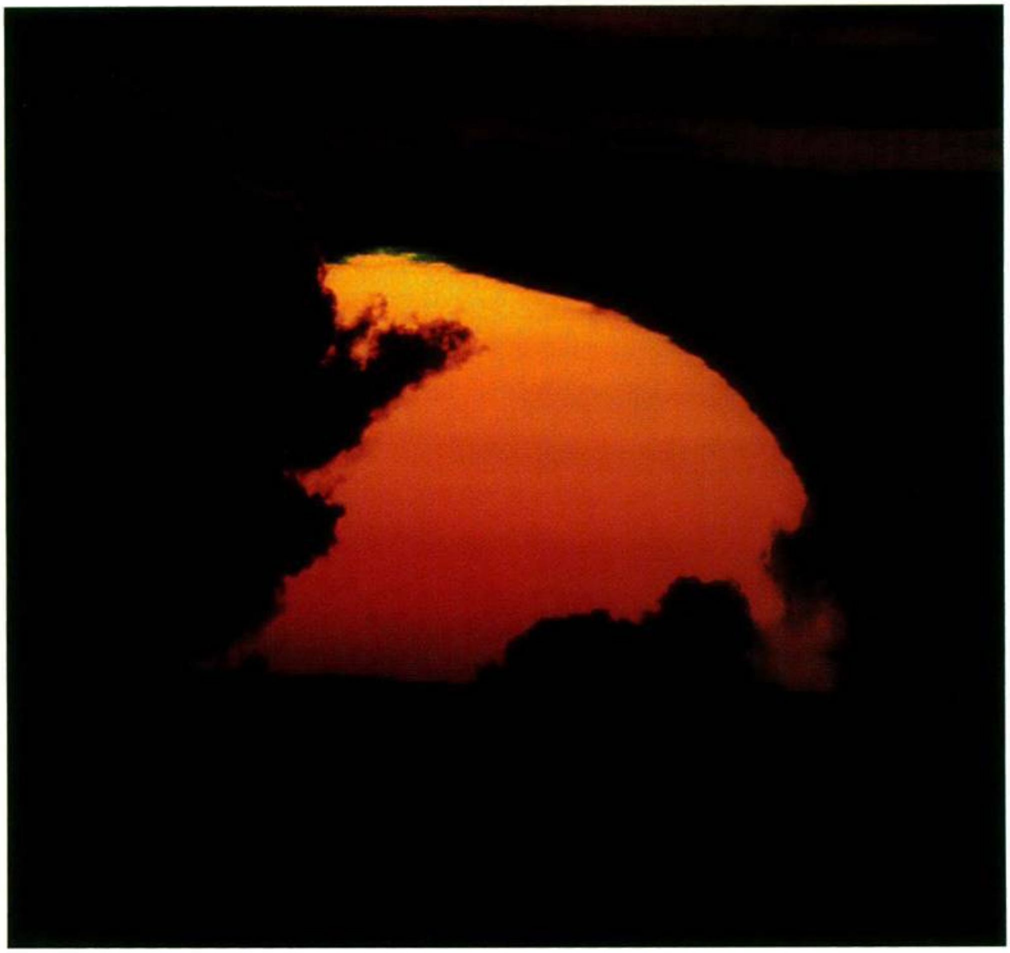
▶ Last summer, I received an invitation to lecture on basic astronomy to high school students in Daet, 345 kilometers south of Manila, on the island of Luzon.

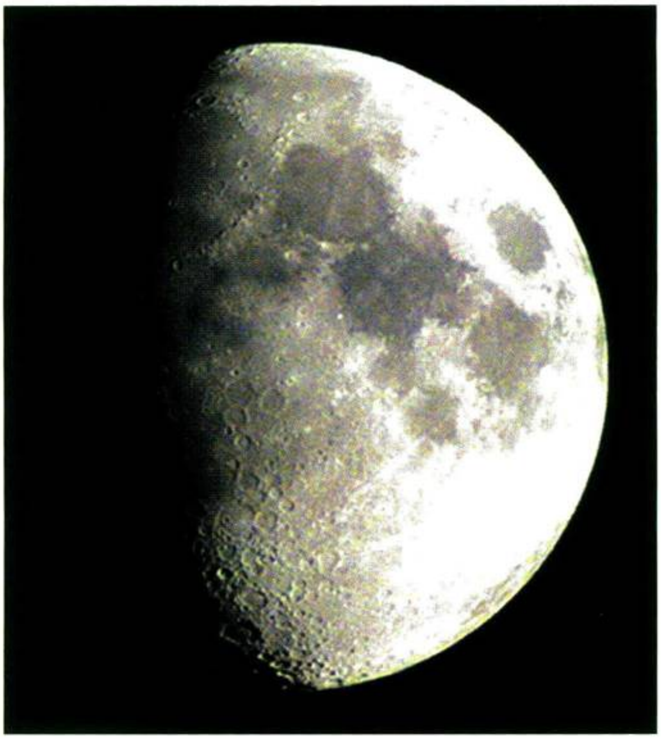
My lecture coincided with the partial lunar eclipse visible in the Philippines on July 5, 2001 — but the rainy weather typical during that time of year concerned me.

As it turned out, my worst fears materialized. Typhoon Feria (international code name: "Utor") blew cloud cover over the entire island of Luzon. On July 3 the weather service issued an alert for Bicol Province, Luzon, where Daet is located.

However, that warning didn't stop me from boarding a bus on July 4 for the eight-hour trip to Daet. Traveling with me were my 8-inch telescope, an LCD projector, compact discs, and my planetary computer program, Starry Night Pro. Most importantly, I also packed high hopes for clear skies the next night. Arlen Petallo, a faculty member of Our Lady of Lourdes College Foundation (OLLCF), met me at the station.

That evening's weather report brought bad news: Northern Luzon was severely damaged by the





**Green Flash in Hawaii**

**MARK SATER**

(5-inch SCT at f/15,
Kodak Elite 200 film,
taken at 6:32 P.M. HST
March 14, 2001)

**Gibbous Moon**

**TODD M. BARRY**

(85mm lens at f/9,
ISO 1600 film,
1/60-second exposure
taken June 29, 2001)

storm, and thick clouds still covered the entire island.

The rain continued through the night and into morning, when Arlen and I appeared on a local TV program, "Hello, Camarines Norte." As we discussed the upcoming lunar eclipse, the TV host asked what benefits came from studying astronomy. I answered, "Astronomy not only teaches us the science of the 'heavens,' but also the virtue of patience."

Afterwards, back at the OLLCF campus, a small group of students waited inside the conference room for the workshop. We planned for 300 students, but expected some cancellations because of the stormy weather. To our delight, attendance eventually swelled to about 400.

By 8:00 P.M. it was still raining, with no signs of clearing. If the weather didn't cooperate, my only option was to "fake" the eclipse using the Starry Night Pro: Its realistic graphics simulate the eclipse in real time. And so, through the computer monitor, we saw the penumbra touch the surface of the moon.

Then — at 9:30 P.M. — just minutes before the moon's predicted entry into Earth's umbra, the clouds broke up. Although visibility was 90%, it was good enough. We raced outside.

Students formed a long queue behind the telescope. All we heard were "Ooohs" and "Aaahs" as they glimpsed the moon close-up. Some of the luckier students witnessed the first contact of the umbra on the moon's limb.

As I scanned the sky, a reddish star appeared from behind the clouds: Antares. Then another one emerged: Mars. I excitedly shifted the scope between views of

**Partial Lunar Eclipse**

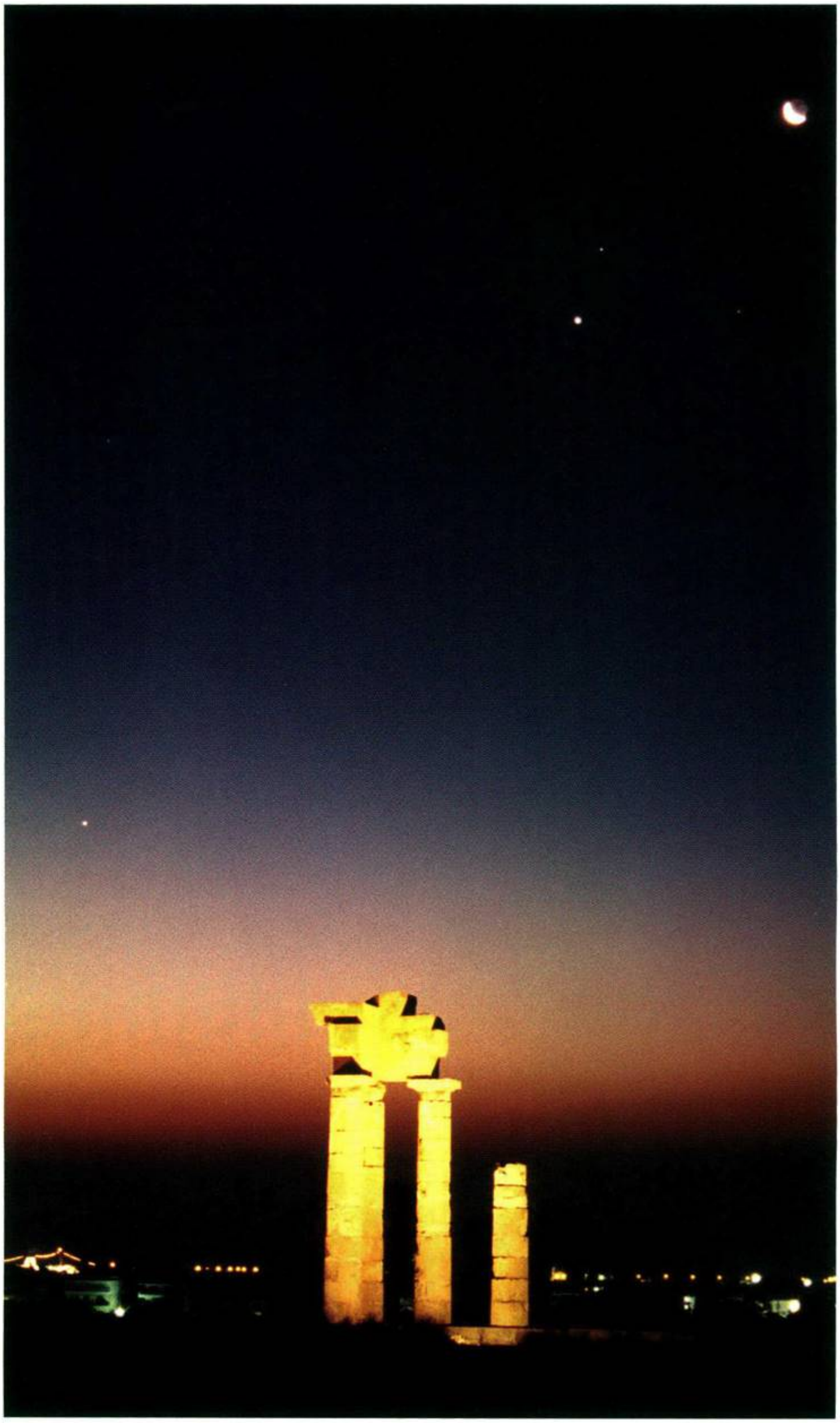
**ALAN DYER**

(4-inch apochromatic refractor at f/6, Extachrome 100 film, ⅛-second exposure taken May 24, 1994)

**The Trifid Nebula (M20)**

**RICHARD D. JACOBS**

(9.25-inch SCT at f/10, SBIG ST-8E CCD camera and CFW-8 color filter wheel, two-hour composite exposure taken May 24, 2001)



**Conjunction over Rhodes, Greece**

**STRATOS KOUFOS AND STERGOS MANOLAKAS**

(50mm lens at f/3.5, Kodak Supra 400 film, 4-second exposure taken July 17, 2001)

Mars, Antares, and the moon. The students measured the angular distance of Mars and Antares using their fingers, a technique learned during the earlier lecture.

Even though the eclipse ended at 1:40 A.M., students were still lining up to view the moon. At 3 A.M. they saw Venus rising 5° above the horizon. As the moon was setting at 5 A.M., we started packing up our things. Sunrise turned the sky a crimson red, illuminating the still-wet OLLCF campus.

On the homeward-bound bus ride, I popped Beethoven's Ninth Symphony into my CD player. While the bus jostled along, I pondered these words from Friedrich von Schiller's *Ode To Joy*:

*Gladly, as His suns do fly*
*Through the heavens'*
*splendid plan,*
*Run now, brothers,*
*your own course,*
*Joyful like a conquering hero*

I guess that I was right after all: Astronomy teaches us the virtue of patience.

---

*Philippine Astronomy Society member Bernie A. Esporlas is a researcher and lecturer at the National Museum-Planetarium in Manila. He was asked to return to Daet in September to give an educational seminar for teachers and other adults.*

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**The Omega Nebula (M17)**

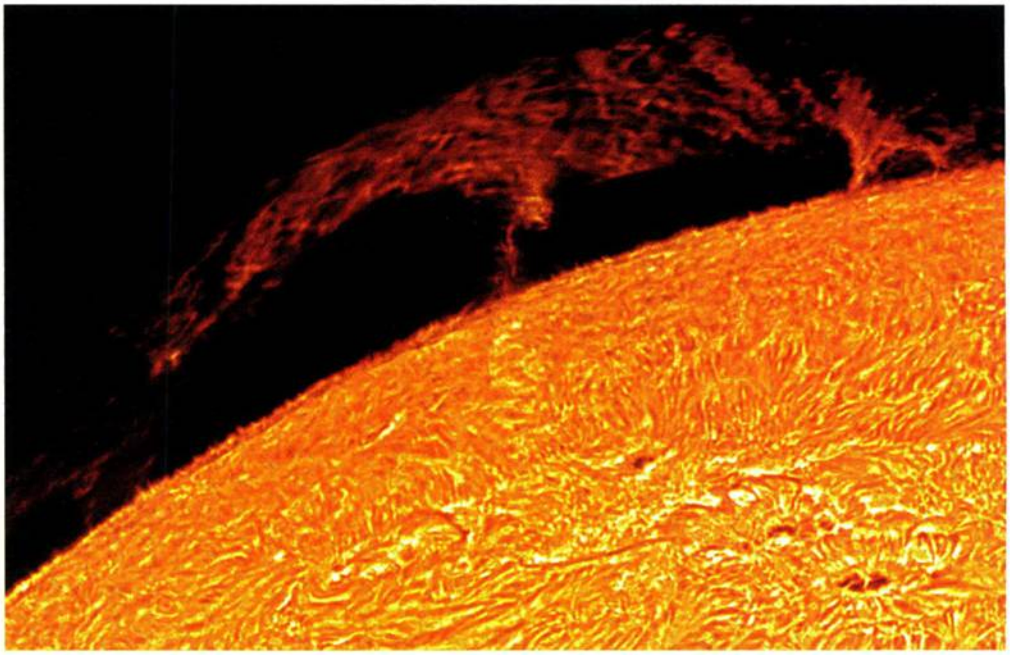
**MATTHEW T. RUSSELL**

(4-inch refractor at f/5, SBIG ST-7E CCD camera, 48-minute composite exposure taken July 24, 2001)

**Mars**

**STEVE CANNISTRA**

(8-inch SCT, Astrovid 2000 camera taken June 29, 2001 )



**Solar Flare**

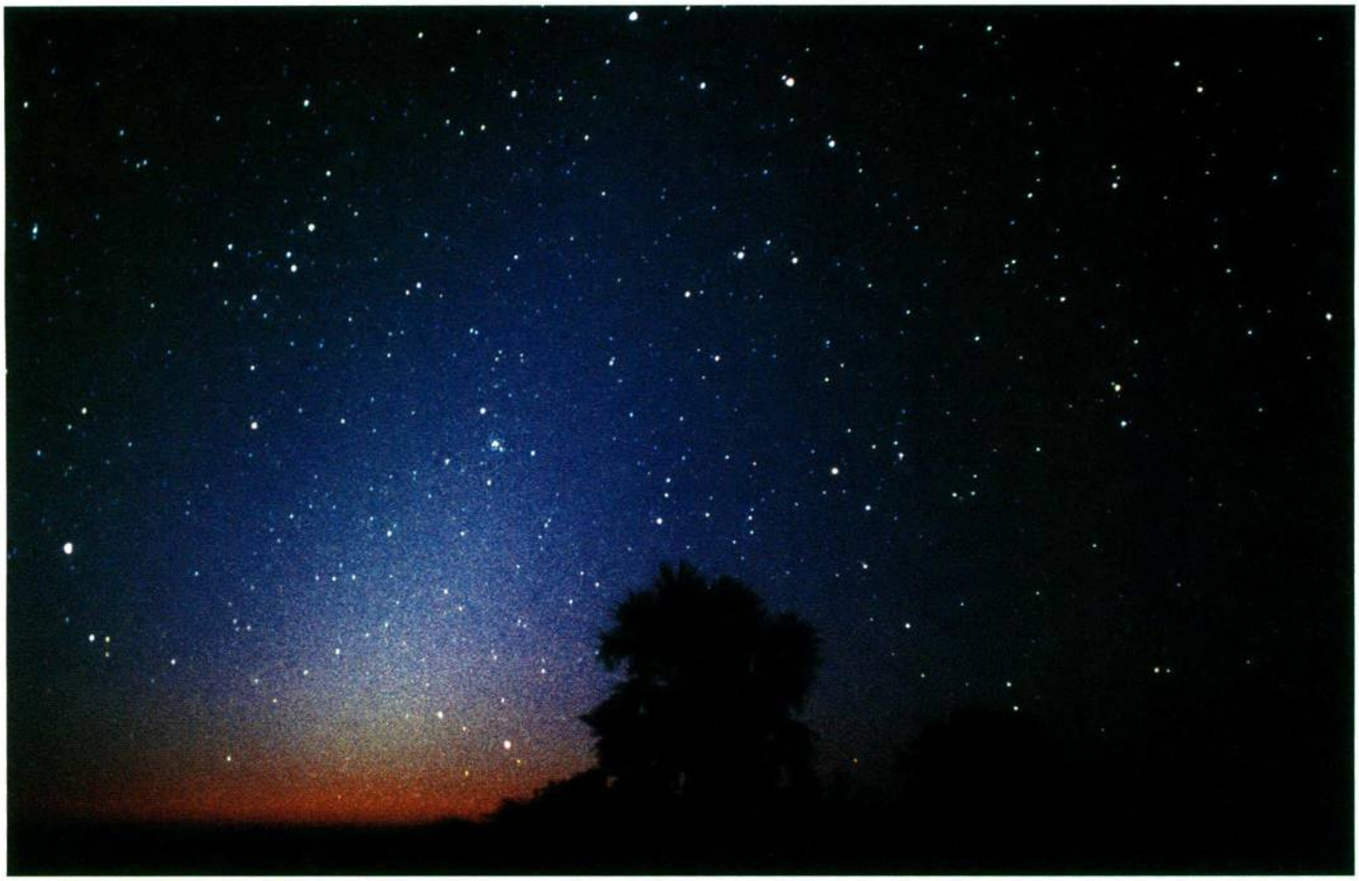
**JACK NEWTON**

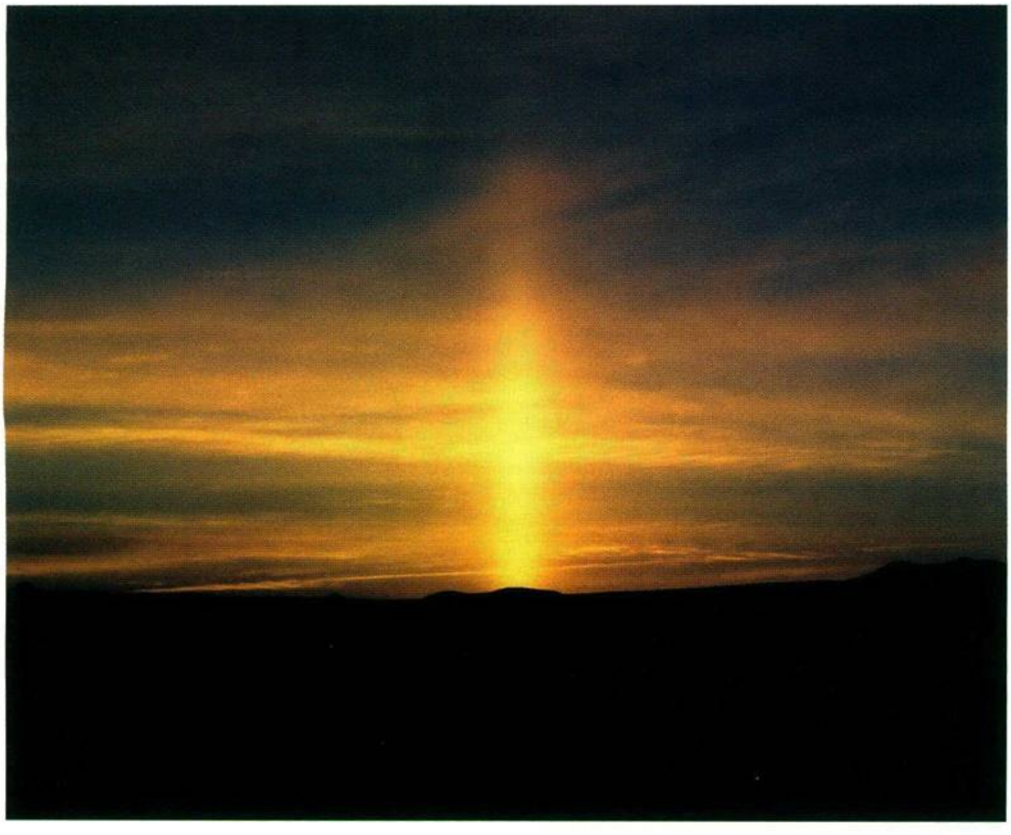
(7-inch apochromatic refractor at f/32 (with 2x Barlow lens), 1/25-second exposure, H-α filter, Pictor 1616XTE CCD camera, taken July 25, 2001)

**The Veil Nebula**

**JEFF RZEPKA**

(10-inch SCT at f/6.3, SBIG ST-8E CCD camera, composite exposure taken July 18, 2001)





**Zodiacal Light in Evening**

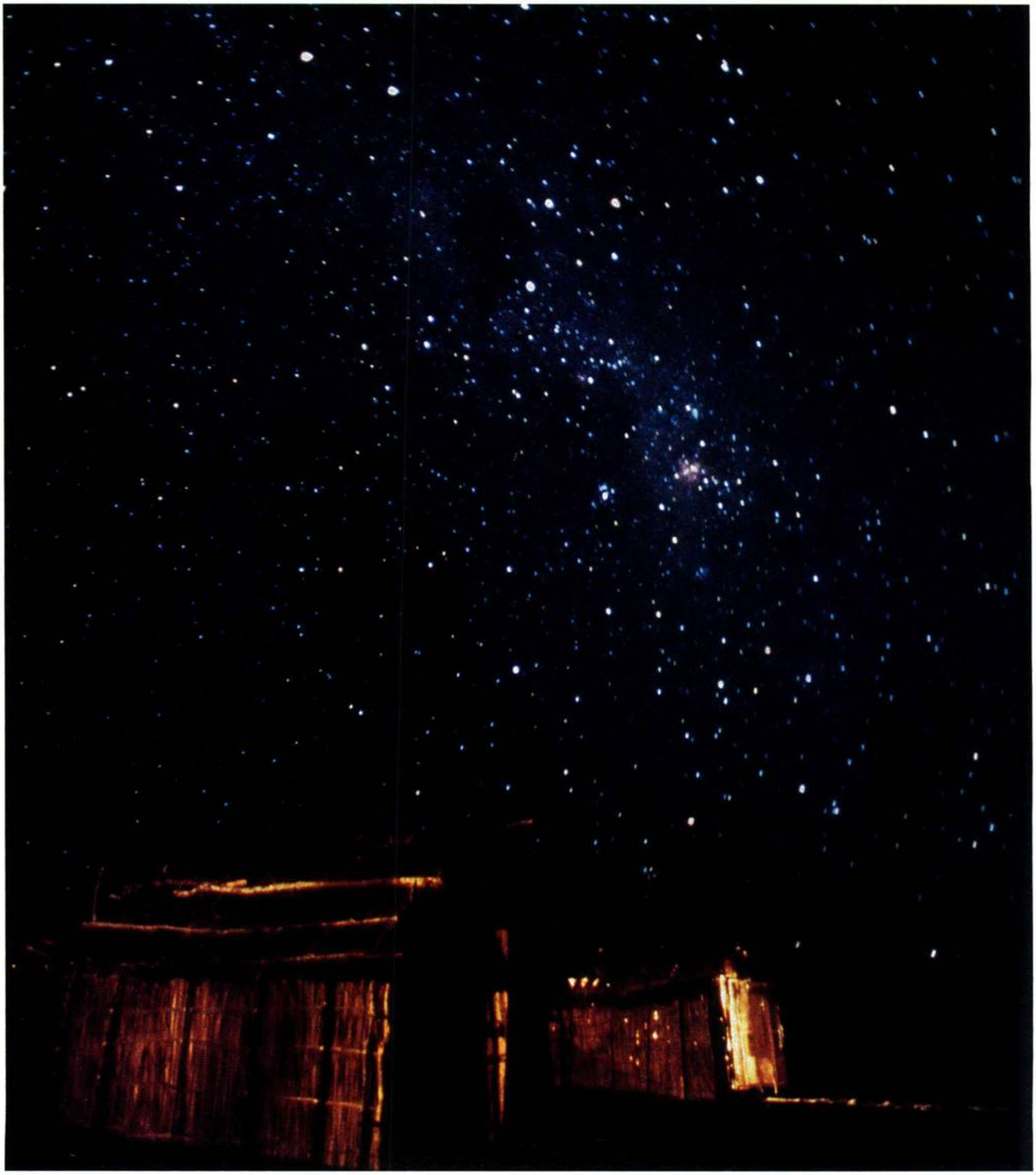
JERRY SCHAD

(24mm lens at f/1.7, Ektachrome P1600 film at ISO 5000, 60-second exposure taken June 21, 2001, from Morombe, Madagascar)

**Sun Pillar**

WILLIAM WOODWARD

(28-200mm zoom lens, Fujicolor Superia 400 film, taken February 10, 2001, near Gillette, Wyoming)



**Southern Milky Way**

JERRY SCHAD

(24mm lens at f/1.7, Ektachrome P1600 film at ISO 5000, 100-second exposure taken June 21, 2001, from Morombe, Madagascar)

Northern Hemisphere residents viewed the Milky Way from a different perspective when they traveled to Madagascar for the solar eclipse — which happened to fall on the Southern Hemisphere's winter solstice as well. These Malagasy-style huts were dubbed "Eclipse Village."

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